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ENGINEERING:

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ROCHESTER. 1108

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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement page 27.
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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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Twenty Gap Bed S.S.C. LATHES, from 4½ in. to 10 in. centres, hollow spindles; standard makers.
Two Excellent VERTICAL DRILLING MACHINES.
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Specification and Workmanship equal to Main Line Locomotives.
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FELLOWS BROS., LTD, 9158
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HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1896

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See illus. Advt. last week, page 15. 1715

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for Water-tube Boilers, Superheaters, Shafting, Hydraulic Work, Boring Rods, &c.
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Cochran MULTITUBULAR AND CROSS-TUBE TYPES **Boilers**
See page 17, Dec. 14. 1134

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DESIGNERS and BUILDERS of all Classes of HANDLING MACHINERY.
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The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
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MANUFACTURERS OF
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RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

Penningtons, University TUTORS, 254, Oxford Road, Manchester. Estab. 1876. Enrol now for A.C.E. and I.M.E. Postal Courses. 100 per cent. passes last Exams. Reinforced Concrete—a new comprehensive course under expert engineer, £3 3s. Write for particulars. 1711

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 617
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 79.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, } Row's Patents.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

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Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM - LONDON.
See Advertisement, page 102. 1111

Special Announcement.
We are now Equipped to
UNDERTAKE the MANUFACTURE of
RIVETTED STEEL CHIMNEYS,
RIVETTED STEEL TUBING,
(For all purposes).
And all descriptions Bent and Rivetted Plates.
Work up to ½ in. thickness.
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Albion Works,
Sheffield.
C 332

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS.
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Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 1586

'Phone—Holb. 541. Tele.—Andrubo, Holb., London.
Andrews & Beaumont,
CHARTERED PATENT AGENTS, 1262
29, Southampton Buildings, London, W.C. 2.

DAVID BROWN & SONS (Hudd.) Ltd.
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HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

GEARS OF EVERY DESCRIPTION.
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Kinnaird House, 1, Pall Mall East, S.W. 1.
Telephone: Regent 3484.

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YARROW BOILERS. 1553

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GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 71, Dec. 14. 2402

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 1483
See Full Page Advt., page 57, Dec. 7.

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 44. Dec. 7. 6195

E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E. 15. 1794

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 1312

For Your Repairs or any SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W. 11.
Est. 1854. 1792

WAYGOOD OTIS LIFTS 1415
54 & 55, FETTER LANE, LONDON, E.C. 4,
62 & 63, LIONEL STREET, BIRMINGHAM,
and Principal Provincial Cities and Abroad.

HEAT INSULATION.
CELITE PRODUCTS CORPORATION,
Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, Dec. 14.

If It Must Be Light, Make it of Aluminium.
Data from British Aluminium Co., Ltd., 109, Queen Victoria St., London. 1369

The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

In the High Court of Justice. 1923.-D. No. 2581.
Chancery Division.
MR. JUSTICE ASTBURY.
IN THE MATTER OF Letters Patent granted to RICHARD DOUST in respect of an invention entitled "Improvements in or relating to Expansion Joints for Pipes subject to varying Temperatures" and numbered 3597 of 1905,
and
IN THE MATTER OF THE PATENTS AND DESIGNS ACTS, 1907 to 1919.

Notice is Hereby Given, that

the above-named Richard Doust and George Henry Folkard have by Originating Summons dated the twentieth day of November, 1923, applied that the term of the said Letters Patent may be extended, AND NOTICE IS HEREBY GIVEN, that on the 22nd day of January, 1924, application will be made to the Court that a day may be fixed before which the said Summons shall not be in the paper for hearing, AND NOTICE IS HEREBY GIVEN, that any person desirous of being heard in opposition to the said Summons must at least seven days before the said 22nd day of January 1924, lodge notice of such opposition at the Chambers of Mr. Justice Astbury, Room 186, Royal Courts of Justice, Strand, London, and serve a copy thereof upon the Applicants.
Dated this 18th day of December, 1923.
C. J. PARKER & SLOAN,
168/173, Temple Chambers, Temple Avenue, E.C.
Solicitors for the Applicants upon whom all documents requiring service may be served.
C 427

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc., Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1295

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1723

TENDERS.

TO ELECTRICAL ENGINEERS.

The METROPOLITAN ASYLUMS BOARD invite separate

Tenders for :—

(A) The INSTALLATION of ELECTRIC LIGHTING in the Kitchen and Nurses' A Home at the Southern (Lower) Fever Hospital, Dartford, Kent.
(B) The INSTALLATION of a FIRE ALARM SYSTEM at South Wharf Smallpox Receiving Station, Trinity St., Rotherhithe, S.E.16,

in accordance with Specifications and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I. Mech.E., Engineer in-Chief. The Specifications, Drawings and Forms of Tender may be inspected at the Offices of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Thursday, 20th December, 1923, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawing have been returned.
Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, 2nd January, 1924.
(By order) G. A. POWELL,
Clerk to the Board. C 447

MACCLESFIELD CORPORATION WATER-WORKS.

TRENTABANK SCHEME.

CONTRACT No. 2—PIPE-LAYING.

The Water Committee invite

Tenders from Competent

Persons for the LAYING and JOINTING of about 5½ miles of 15-inch, about ¼ mile of 18-inch, 12-inch, 9-inch and 3-inch CAST-IRON PIPES, together with the fixing of the necessary VALVES, etc., and the construction of STREAM CROSSINGS, VENTURI METER HOUSE, BREAK-PRESSURE TANK, etc., between Langley and Leadbeaters, Macclesfield.
The Conditions of Contract, Specification, Schedules and Forms of Tender prepared by the Engineer, HERBERT LAPWORTH, D.Sc., M.Inst.C.E., 15, Victoria Street, Westminster, S.W. 1, may be obtained on application to me on and after the 24th inst., accompanied by a cheque for Five Guineas, which will be refunded on receipt of *bona fide* Tenders and the return of all documents.
Copies of the Plans and Drawings will be available for inspection at my Office on or after the 29th inst. For the convenience of Contractors, Dr. Lapworth will attend at the Town Hall on Tuesday, the 1st day of January, 1924, between the hours of TEN a.m. and THREE p.m.
Sealed Tenders, endorsed "Tender for Pipe Laying," must be delivered to me at my Office not later than Saturday, the 12th day of January, 1924.
The Committee do not bind themselves to accept the lowest or any Tender.
F. R. OLDFIELD,
Town Clerk.
41, Churchside, Macclesfield.
17th December, 1923. C 428

CITY OF LIVERPOOL.

NEW STEAM HOPPER BARGE.

The Corporation of Liverpool Require A NEW STEAM HOPPER BARGE suitable for House Refuse, of approximately 1000 tons capacity, and are prepared to receive

Tenders from Shipbuilders

and Engineers.
Copies of Specification, General Conditions, and Form of Tender will be forwarded upon receipt of application in writing to :—
The City Engineer,
Municipal Buildings,
Dale Street, Liverpool.
Sealed Tenders addressed to "The Town Clerk, Municipal Buildings, Liverpool," and endorsed "Tender for New Steam Hopper Barge," must be forwarded through the post so as to be received NOT LATER THAN TWELVE O'CLOCK NOON, ON TUESDAY, THE 22nd JANUARY, 1924.
WALTER MOON,
Town Clerk.
11th December, 1923. C 398

CITY OF NOTTINGHAM.

TRENT BRIDGE WIDENING.

Contractors Desirous of

Submitting TENDERS for the above WORK are requested to send in their names immediately to Mr. T. WALLIS GORDON, City Engineer and Surveyor, Guildhall, Nottingham.
The work will probably be divided into Contracts comprising :—
(A) Steelwork.
(B) Construction of Piers and Abutments.
Applications will only be considered from firms having had recent experience in bridge construction.
W. J. BOARD,
Town Clerk.
Guildhall, Nottingham.
17th December, 1923. C 432

TO HEATING ENGINEERS.

The METROPOLITAN ASYLUMS BOARD invite

Tenders for Alterations and

Additions to existing LOW PRESSURE HOT WATER HEATING APPARATUS installed in Ward Blocks Nos. 5 and 7 at Darenth Training Colony, Dartford, Kent, in accordance with Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawings and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C. 4, on and after Ten a.m. on Wednesday, December 19th, 1923, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.
Tenders, addressed as noted on the Form, must be delivered at the Office of the Board, not later than 2.30 p.m. on Wednesday, January 2nd, 1924.
(By order) G. A. POWELL,
Clerk to the Board. C 423

COUNTY BOROUGH OF SUNDERLAND.

ELECTRICITY DEPARTMENT.

The Corporation of Sunderland invite

Tenders for the Supply and

INSTALLATION of the following PLANT at their Hylton Road Electricity Works :—
SECTION A. One 10,000 kilowatt Alternator Turbine and Condensing Plant.
SECTION B. Two Straight Tube Water Tube Boilers, each of 50,000 lbs. evaporative capacity per hour.
SECTION C. Natural draught Wooden Cooling Towers and Concrete Foundations.
Copies of the Specification and Form of Tender for each Section separately may be obtained from the General Manager, Electricity Offices, Dunning Street, Sunderland, upon payment of a deposit of Three Guineas for each Section in duplicate. The deposit will be returned only after a *bona fide* Tender has been received and adjudicated upon, and provided the same has not been withdrawn.
Sealed Tenders, endorsed on cover "Tender for Electricity Works, Section A, B or C," (as the case may be), are to be addressed to the Chairman of the Electricity Committee and delivered at the office of the undersigned, Town Hall, Sunderland, not later than the first post on Monday, the 21st January next.
The Corporation do not bind themselves to accept the lowest or any Tender.
H. CRAVEN,
Town Clerk.
Town Hall,
Sunderland.
10th December, 1923. C 383

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
VICTORIA,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.
Copies of Tender Form and Specification will be available upon application to :—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/4.—
4 ONLY 100 K.V.A. 25,400-6600 V. TRANSFORMERS, AND SPARES.

CHARGE :—10/- for the first two copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third copy and any further copies will be supplied for the sum of 5/- each. This charge is not returnable.
PRELIMINARY DEPOSIT :—A Preliminary Deposit of £10 is to be lodged with Tender.
The Specification may be inspected at the above-mentioned office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 11th February, 1924.
R. LIDDELOW,
Secretary. C 440

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

Five Thousand-100 ton SCREW COUPLINGS.
Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C.2, on or after 18th December, 1923.
A fee of £1 will be charged for the Specification, which is NOT returnable.
Tenders must be submitted not later than NOON on Monday, 7th January, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
R. C. VOLKERS,
Secretary. C 433

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for :—

138 STEEL ENGINE TYRES.
Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after 19th December, 1923.
A fee of 10s. will be charged for the Specification, which is NOT returnable.
Tenders must be submitted not later than NOON, on Thursday, 3rd January, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
R. C. VOLKERS,
Secretary. C 435

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

3500 BUFFER PLUNGERS AND 4000 BUFFER CASES.
Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C.2, on or after 17th December, 1923.
A fee of £1 will be charged for the Specification, which is NOT returnable.
Tenders must be submitted not later than NOON on Friday, 4th January, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
R. C. VOLKERS,
Secretary. C 425

GREAT NORTHERN RAILWAY (IRELAND).

The Directors are prepared to receive

Tenders for Supply of :—

BULL HEAD RAILS.
FLAT BOTTOM RAILS
and
FISHPLATES
(of British Standard Sections);
also
CAST-IRON CHAIRS
and
PERMANENT WAY FASTENINGS.
Specifications and Drawings can be obtained from the undersigned.
Tenders, made out on forms supplied by the Company, should be delivered, under sealed cover endorsed "Tender for Rails, etc.," not later than TEN a.m. on Friday, 18th January, 1924.
The Directors do not bind themselves to accept the lowest or any Tender.
J. B. STEPHENS,
Secretary.
Amiens Street Station, Dublin,
18th December, 1923. C 439

APPOINTMENTS OPEN.

THE ROYAL SOCIETY.

ARMOURERS AND BRASIERS' COMPANY RESEARCH FELLOWSHIP IN METALLURGY.

The Secretaries of the Royal Society are prepared to receive

Applications for the above

RESEARCH FELLOWSHIP.
Provided applicants of sufficient merit apply the successful candidate will be required to enter upon a course of research which must be connected with base metals and alloys, and preferentially those used in connection with the Ancient Crafts of the Company of Armourers and Brasiers. The research is to be carried out under the scheme approved by the Royal Society and the Armourers and Brasiers' Company. The appointment will be for two years in the first instance, but may be extended to five years.
The stipend will be £500 per annum, dating from the commencement of the research.
Applications must be received at the Royal Society not later than March 1st next. Applicants will be required to state their academic qualifications, the research work already carried out by them, and to give three references.
THE ROYAL SOCIETY,
Burlington House, W.1. C 419

UNIVERSITY OF BIRMINGHAM.

FACULTY OF SCIENCE.

PROFESSORSHIP OF CIVIL ENGINEERING.

The Council of the University invites

Applications for the Chair

of CIVIL ENGINEERING.
The stipend will be £1000 a year.
The Professor will be allowed to take Higher Consultative work, to keep in touch with Civil Engineering practice, provided that it does not interfere with his University duties.
Applications, accompanied by fifty copies of testimonials, should be received by the Secretary not later than February 4th, 1924.
The successful candidate will be expected to begin his duties on October 1st, 1924.
Further particulars may be obtained from
GEO. H. MORLEY,
Secretary. C 382

The Stanton Ironworks Com-

PANY, LIMITED, near Nottingham, REQUIRE the SERVICES of a FOUNDRY WORKS MANAGER.—Apply, in writing, enclosing photograph, to the FOUNDRY GENERAL MANAGER. C 304

Experienced Manager

REQUIRED for large Steel Foundry (North East Coast) carrying out Warship, Merchant Marine, Locomotive and General Work. State when available and remuneration required.—Address, C 446, Offices of ENGINEERING.

Wanted, Power Station

SUPERINTENDENT for North Midlands, age under 40. Thorough experience Stirling Boilers and Turbo Generators. No testimonials with application. Salary £360.—Address, C 422, Offices of ENGINEERING.

Head Rate Fixer Wanted

for Marine Engine Works, North East Coast. Previous experience in similar work and knowledge of Marine engine works practice essential. Address, giving full particulars, references and salary, C 424, Offices of ENGINEERING.

Traveller Required, for

London area, for the sale of Extruded Brass Rods, by one of the leading manufacturers. Must have first-class knowledge of the trade, none others need apply. State experience (fully), in confidence, age, and salary required.—Address, C 453, Offices of ENGINEERING.

The Royal Air Force

REQUIRES SKILLED FITTERS General (for training as Aero Engine Fitters), Fitters Driver Petrol, Electrical Fitters and Power Station tradesmen. Age limits:—Ex-Service men 18 to 30; Non-Ex-Service 18 to 26; highly skilled Fitters up to 35. Ex-N.C.O's up to 38 years (with rank according to trade ability). Pay from 24s. 6d to 68s. 6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call :—INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, W.C. 2. B 759

Engineer Wanted by a Large

Firm of Engineers in the Midlands to take control of the engineering side under the Managing Director. Applications only desired from those having the highest qualifications and experience in the design and manufacture of heavy oil and gas engines. State age, experience and salary required. Applications will be treated as strictly confidential. —Address, C 386, Offices of ENGINEERING.

Required, Engineer-Salesman

(high-class) for JAPAN. State qualifications and salary required.—Write, BOX, No. 698, Advertising Offices, 84, Queen Victoria Street, London, E.C. 4. C 434

Sales Engineer Required as

outside representative (to travel the country) by firm of Mechanical and Constructional Engineers. Energy and an attitude for securing business essential. State age, married or single, experience and salary expected.—Address, C 442, Offices of ENGINEERING.

Pump Designer with Experi-

ence of Multi-stage Pumps REQUIRED. Good general and practical experience necessary. Replies must give age, details of experience and salary required.—Address, C 443, Offices of ENGINEERING.

Required, First-class

DRAUGHTSMAN, competent on Railway and Tramway Traction Motor work.—Apply, THE ENGLISH ELECTRIC CO., LTD., Dick, Kerr Works, Preston. C 385

Draughtsman Wanted, used

to design of electric trucks and tractors, with general experience. State age, salary, full experience.—Address, C 429, Offices of ENGINEERING.

Draughtsman, Junior,

WANTED, with experience in the preparation of engineering drawings and diagrams for book illustration purposes. State age, salary and experience.—Address, C 449, Offices of ENGINEERING.

Draughtsman (Temporary)

REQUIRED, for Motor firm in the Midlands. Must be experienced in Light Car designs. The position carries prospects and may prove a permanency.—Address, C 438, Offices of ENGINEERING.

Several Junior Structural

DETAIL DRAUGHTSMEN WANTED at once for temporary work; must be quick and accurate.—Write, stating age, experience and salary required, to FRASER & CHALMERS ENGINEERING WORKS, Erith, Kent. C 426

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Experienced DRAUGHTSMEN WANTED, accustomed to High Speed Heavy Oil Engine Work. Must be quick and accurate. Particulars of experience, age and wages desired. — Address, "ACCURATE," WM. PORTEOUS & Co., Advertising Agents, Glasgow. C 444

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MAN, accustomed to high pressure hydraulic work.—Apply, by letter, stating age, experience and wage required, to THE HYDRAULIC ENGINEERING CO., LTD., Chester. C 421

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Steam Turbine details and Power Station Layouts.—Write, stating age, training, experience and salary expected, to CHIEF DRAUGHTSMAN, ENGLISH ELECTRIC CO., LTD., Rugby. C 455

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THE THERMAL PROPERTIES OF ETHYL CHLORIDE.

ETHYL chloride is one of the substances that have recently been under investigation for the purposes of mechanical refrigeration. Its comparatively high boiling point (12·5 deg. C.) enables it to be handled in open vessels at ordinary temperatures without much loss, and to be stored in glass bottles or quite tight metal cylinders; it does not attack iron or other metals used in machine construction; for commonly used temperatures only quite low pressures and moderate vacua are required, *e.g.*, 19·4 and 3·5 lbs. per square inch abs. for ± 20 deg. C.—so that simple compressors of the Roots type are sufficient; and though the low pressure involves very much larger pumps and pipes than are required for refrigeration by carbonic acid or ammonia, they can be made very light, and the machinery is particularly safe. The anæsthetic effect of the vapour is not appreciable unless it is inhaled in considerable strength; no discomfort from this cause was found, for example, during the experiments described below.

The liquid can dissolve a small quantity of water, and on evaporation in the presence of water—as for instance when exposed to the atmosphere or if any water has been dissolved in it—it produces what appears to be tubular ice crystals, up which the liquid ethyl chloride is absorbed as by a sponge, and by its further evaporation causes them to grow rapidly. In a refrigerating machine the liquid has thus to be kept perfectly dry, as otherwise the crystals formed on evaporation will rapidly choke up the throttle valve; and the use of a reciprocating compressor is, therefore, unsuitable for the purpose, as the glycerine with which the piston rod has to be lubricated takes up atmospheric moisture and carries it into the cylinder, where it dissolves in the liquid. There appears at present to be no known heat-insulating material that will resist liquid ethyl chloride. Pure rubber is softened almost to solution; vulcanised rubber swells considerably and leaks, though it is said to return to its usual size when the ethyl chloride dries off; vulcanite and most woods also swell; and where a non-conductor is really required for valves, &c., lignum vitæ is the best in practice, bakelite, which appears to be the least affected, being mechanically too weak for any but experimental purposes. The most serious disadvantage of the substance is its aptness to catch fire, and to form with air explosive mixtures when it is present in any proportions lying between 4·9 per cent. and 13·5 per cent.; figures which compare with 1·5 and 6·4 per cent. for petrol and 16·5 and 26·8 per cent. for ammonia. Where this risk cannot be otherwise avoided, the probable remedy is to mix the ethyl chloride with a substantial percentage of methyl bromide. This produces a mixture that is not only non-flammable but can actually be used as a fire extinguisher, and is said to have refrigerating properties not very different from those of ethyl chloride itself, though presumably fresh charts would have to be prepared if its general use was contemplated. Commercial ethyl chloride contains a little methyl chloride, itself another possible working substance for refrigerating machinery; the effect of it in ethyl chloride would be to raise the vapour pressure slightly.

Reference is made to most of these facts in the Special Report No. 14, just published by the Food Investigation Board,* which contains the results of an investigation undertaken at the request of its Engineering Committee by Professor C. F. Jenkin, and of experiments carried out by him at the Engineering Laboratory of the University of Oxford with the assistance of Mr. D. N. Shorthose. The object of the report was principally to measure the thermal properties of ethyl chloride for the use of refrigerating engineers, and the chief results are given in three tables and in $\theta\,\phi$ and $I\,\phi$ charts. Having regard to the convenient and considerable practical use that designers make of the $I\,\phi$ diagram the Stationery Office has arranged to supply spare unfolded copies at 3*d.* each. The ethyl chloride used in the experiments was not chemically pure, but contained less than 0·3 per cent. of methyl chloride and less than 0·1 per cent. of water; it was also neutral to litmus paper.

The thermal measurements were made in continuous flow calorimeters, heated electrically, which were intercalated in the circuit of a vapour compression refrigerating machine. The circuit also included a weighing tank, holding about 30 lbs. of ethyl chloride and turning with $\frac{1}{10}$ lb., from which the ethyl chloride flowed into the calorimeter for evaporation, and a spare tank, into which it returned after evaporation and recondensation while the actual text was in progress. The arrangement thus permitted a steady flow of ethyl chloride round and round the circuit for so long as was desired. Thus, for instance, in determining the latent heat the liquid flowed from the weighing tank through a throttle valve into an electrically heated evaporating tray, both of them in the calorimeter, and the vapour passed on through a calcium chloride drying tube and a 2-in. valve into the pump. There it was compressed and delivered into a condenser, whence it passed through a glycerine separator into the spare tank. A simple and ingenious electrical arrangement enabled the level of liquid on the evaporating tray to be kept constant during the test, and an auxiliary heating coil above the liquid served to give a slight superheat to the vapour. Platinum thermometers took the temperature of the liquid immediately before it entered the throttle valve, and of the vapour as it left the calorimeter. Before a test the liquid was run round and round the circuit with the weighing tank (the spare tank being temporarily short-circuited) until a constant regime had been established, when the spare tank was reconnected into the circuit through a valve, and received the liquid as it was condensed throughout the test. Evaporation took place at an accurately measured temperature round about 5 deg. C. and at the rate of about 0·6 lb. per minute. The initial temperature of the liquid (about 14 deg. C.) and the final temperature of the gas (about 20 deg. C.) being different from the temperature of evaporation, the latent heat could not be calculated from the measurements made on the above circuit until the specific heats of liquid and vapour had been determined. It worked out ultimately at 92·96 for 5 deg. C. by interpolation from the results of those tests, in each of which from 15 to 21 lbs. of liquid was evaporated. These figures are recognised as being a trifle high owing to the presence of traces of water. The values of the latent heat for other temperatures from + 40 to − 30 deg. C. were taken from the $\theta\,\phi$ chart.

In the determination of the total and specific heats of the liquid the same pump, condenser, separator and weighing tanks were used, but the liquid from the tank flowed through a horizontal calcium chloride drying tube, a Venturi meter read by an inverted glass U-tube with some air in the top, and a grid of copper tubes in which it is cooled to the desired temperature. From there it flowed into a calorimeter, where it was heated electrically, and thence into a tubular evaporator immersed in an electrically-heated bath of water or methylated spirit. The vapour then passed to the pump and through the condenser back to the tank. The measurements from low to atmospheric temperatures were arranged with the calorimeter one way up, and from atmospheric to high temperatures the other way up, the calorimeter being so designed that in this way the outside was always at about atmospheric temperature. The actual measurements made were of the initial and final temperatures of the liquid (taken with platinum thermometers) and of its pressure. From these the heat absorbed by the liquid in each test and its specific heat between the temperatures in question were calculated, and with the help of pressure and specific volume determinations at 0 deg. C. and the verification of the fact that the compressibility of the liquid is negligible, the total heat was deduced from the known relation that at 0 deg. C. $I = A\,p\,v$, where A is the reciprocal of the mechanical equivalent of the thermal unit.

The total heat of the vapour was measured by similar arrangements, except that the liquid from the Venturi meter passed through a throttle valve into an auxiliary evaporator on its passage into the main evaporator, and means were provided for keeping a constant level of liquid accumulating in the evaporator, so as not to falsify the measurements of the rate of flow of the liquid. The heat required by the vapour in these tests was small, and it was found necessary to run for about an hour before beginning each test, to avoid interference with the results through the heat capacity of the calorimeter. The measurements gave the initial and final superheated vapour temperatures at a pressure kept constant throughout each test, and thus enabled the heat added to the vapour per pound to be calculated. By using the results of several tests made at approximately the same constant pressure in context with the total heat of the liquid and the latent heat at 5 deg. C., the total heat of the superheated vapour at that pressure and at various temperatures were calculated and plotted. With the help of the other total heat measurements in this series and of the results of the throttle experiments next described similar curves were plotted for various other constant pressures, the lower ends of the curves, where they cut the corresponding saturation temperatures, fixing the "boundary curve." From these curves and the $I\,\phi$ chart values were obtained for the total heat and specific heat of the vapour.

With a similar arrangement, but with a throttle valve in bakelite substituted for the central part of the calorimeter in which the vapour was heated in previous tests, determinations were made of the pressure and temperature on each side of the throttle valve, covering the whole range of the pressures and temperatures used in the investigation. Alterations of design were found necessary to prevent the thermometer readings from being affected otherwise than by the temperature of the vapour, but ultimately consistent readings were obtained. As has been seen, these enabled the latent heat determinations for various temperatures to be calculated by a measurement made at one temperature only, and the total heat by a full series of measurements made at one pressure only, single measurements near the boundary curve being made at other pressures.

By ordinary laboratory methods in glass apparatus measurements were also made of the saturated vapour pressure from—30 deg. to + 40 deg. C., of the density, dilatation and compressibility of the liquid, and of the solubility of water and of air in the liquid. It was found that a small amount of water must have been introduced by way of the piston rod in the earlier determinations of the latent heat, but the drying tube avoided this completely in later measurements. The extent to which air was soluble in the liquid was found insufficient to affect the measurements appreciably. From the measurements of density, dilatation and compressibility, the specific volumes of liquid ethyl chloride at temperatures from 30 deg. to + 30 deg. C. were calculated.

These data have enabled charts to be prepared showing the relations of temperature with total heat and entropy respectively, and from these the $I\,\phi$ chart over the full range investigated.

The figures of latent heat are a little lower than those that can be inferred from Regnault's determination of the total heat of the liquid when raised from 0 deg. C. to 12·5 deg. and 21 deg. respectively and evaporated at those temperatures, after correcting for the total heat of the liquid alone. As already pointed out, some of the present figures are known themselves to be a trifle high through the presence of traces of moisture. Regnault's figures of total heat are said, moreover, to be often quoted as values of the latent heat, and the errors thus introduced would be considerable.

A still more notable discrepancy between existing results and those obtained in this investigation is in the specific heat. The only determination previously available was one made and (without a description of methods) quoted by Regnault, which put the specific heat between − 28 deg. and + 4 deg. C. at 0·4276, against the value 0·366 found for the same mean temperature in the present experiments. The present figure was confirmed substantially by two sets of determinations made on another method.

Satisfactory agreement with previous results was found in the figures for total heat of vapour

* The Thermal Properties of Ethyl Chloride. By C. F. Jenkin and D. N. Shorthose. H. M. Stationery Office. 2*s.* 6*d.* net.

and dilatation of liquid. Discrepancies in those for vapour pressures were observed, but the cause was not cleared up; no particulars seem to be available of the precise degree of purity of the substance used in the earlier investigation. There are also small discrepancies in the figures of density and compressibility of liquids, though the extent seems too small to have practical significance.

As a whole the report gives results that are both of practical value and scientific importance. Further work on the same lines is understood to be in progress on other substances.

THE STUDY OF STRESS-STRAIN PROBLEMS BY MEANS OF RÖNTGEN RAYS.

(*Concluded from page* 751.)

So far the specimens had not been stressed after preparation. In the next series of experiments they were submitted to Brinell hardness tests, the Brinell ball of 2 mm. diameter being forced into a slab of the single crystal as indicated in Fig. 25. The Laue pattern of the original specimen was very much like that of Fig. 5. In Fig. 26 we see the result of forcing the ball in under a pressure of 1 kg., the indentation produced having a diameter of 0·3 mm. The full round dots have quite changed their appearance and, to a lesser extent, also their relative positions; the dots look more like drawn-out lenticular curves. As the pressure is increased to 3 kg. and to 5 kg., Figs. 27, 28, the lenticular shape becomes more pronounced, and the lower dots approach the dark central spot more and more closely; the dots also develop radial appendages. In Fig. 29 the pressure has been raised to 10 kg., a larger ball being used; the impression circle has assumed a diameter of 1 mm., and the separate dots are no longer distinguishable; a radial star pattern has developed, "asterism" as Czochralski calls it. That a slight deformation beyond the elastic limit is sufficient to cause a marked change in the pattern was further shown by pricking a crystal with a steel needle to a depth of only 0·1 mm.; the round dots began to assume lenticular shapes.

One might fancy that stress having such striking consequences must directly be visible in other ways. But an experiment with a crystal of gypsum disproves that. A straight crystal of gypsum (not illustrated) was cautiously bent to the shape shown in Fig. 30; no cracks were developed, and there was no turbidity, the crystal remaining perfectly transparent. But the Laue diagrams show profound changes; Fig. 31 was taken before the bending and Fig. 32 after it. The rays fell in normal to the crystal face, and the pattern of Fig. 31 is hence symmetrical and central with respect to the spot hit. In Fig. 32 the separate dots have united to elliptical forms, no longer showing circular curves and rays.

Since the originally straight crystal had been bent, one might expect to find that it had assumed the structure of an arch whose bricks radially diverged from one another; but the microscopic examination showed no traces of radial clefts, which should have been visible if they had had a width of even as little as 0·0001 mm., nor did mechanical tests suggest any diminution of strength. Czochralski hence considered that the distortion must have affected the atomic grouping.

He proceeded to experiments with single aluminium crystals first stretched in a tension machine and then, when they had been broken, rolled out further. The round dots became slightly displaced and elongated, some appeared striated, and asterism developed, the star rays becoming both shorter and less intense as the strains increased. In the next similar series of experiments, the results of which we reproduce in Figs. 33 to 38, single crystals of aluminium were simply rolled down in steps, finally to the finest foil procurable. In Fig. 33 the cross-section of the specimen has been diminished by 5 per cent.; the general pattern is not much changed, but several of the dots appear elongated, rays are developing, and there are marked changes in the relative intensities of the dots and rays. These changes are more pronounced in Fig. 34, after reduction of the cross-section to one-half; a comparison with another specimen which had been stretched on a tension machine would show that the main development of the rays is now in a different quadrant.

In the specimen shown by Fig. 35 the direction of rolling had been changed by 90 deg.; the additional reduction in cross-section amounted to 15 per cent., and new rays appear making an angle of about 30 deg. with the direction of the last-applied stress. Rolling in this same direction was continued until another reduction of nearly 40 per cent.—the possible limit—was attained; only three rays are distinct in Fig. 36, and the whole system of rays seems to have turned anti-clockwise, the star rays which so far seemed to have kept steady in position, taking part in this motion and pointing downwards.

It will be noticed that the asterism rays appeared preferentially in certain quadrants. That is not surprising. Complete symmetry in the four quadrants could only be expected with perfect cubical crystals struck normally to one of the cubical faces. Aluminium crystals are cubical; but their orientation to the pencil of X-rays was unknown, and the direction of rolling would be a factor of importance. This is further exemplified by the diagrams, Figs. 37, 38. The unstressed specimen gave the pattern Fig. 38; after reducing the cross-section by 70 per cent. (by rolling), the pattern Fig. 37 formed an almost symmetrical star, but with rays of unequal intensity. In special experiments patterns were obtained such as should result under varying conditions of orientation, keeping both the direction of the rays and the direction of rolling normal to the one or the other of the cubical faces. There were, *e.g.*, 9-cornered stars (with three prominent rays at 120 deg.), or 6-cornered stars (with four rays alone developed). These patterns were imitated by further experiments with heaped-up minute crystals. Another observation should be mentioned. We have seen that as the number of crystallites in the field increased, the dots became smaller and fainter. If the grain were really the determining factor, recrystallisations of a very fine-grained metal or of a heap of minute crystals should re-transform a halo into a pattern of dots. In this way the diagrams, Figs. 23, 21, 19, were, in fact, reproduced by progressive recrystallisation, in the reverse order in which we have previously mentioned them.

Summing up, it would appear that, as stress is being applied the dots of the radiogram become striated and relatively displaced both radially and tangentially. As the distortion advances, radial lines replace the dots; some of these lines increase in intensity, new rays appear and the most intense rays undergo a partial rotation about their centre, setting themselves parallel or at right angles to the direction of the stress. The general aspect of the pattern depends upon the orientation of the crystal to the X-rays and to the direction of the stress; reversal of the direction of the stress reverses the sense of the rotation. Finally the radial grouping vanishes, and the overstrained material begins to resemble a heap of very minute crystallites or an amorphous material. Recrystallisation restores the original pattern of separate diffraction dots. Superior resolution, we should think, might possibly bring out some patterns even in the halos of amorphous solids. There may be no difference in principle between crystalline and amorphous substances, as Debye and Scherrer suggested after their X-ray examination of the different modifications of carbon*; the grouping of the atoms in solids may always be subject to certain, more or less marked regularities.

But Czochralski insists upon the striking differences in the two types of phenomena, exhibited by single and multiple crystals or metals of finer and finer grains on the one hand, and by strained metals on the other hand, as exhibited by Figs. 7 to

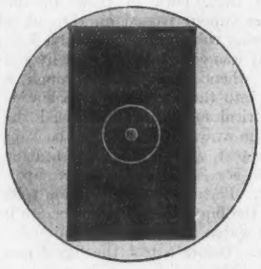


Fig. 25.

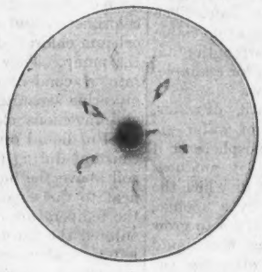


Fig. 26.

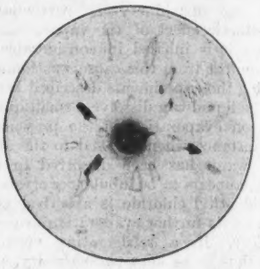


Fig. 27.

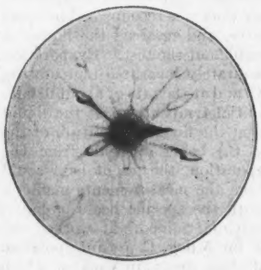


Fig. 28.

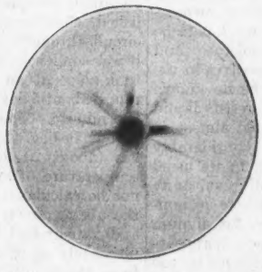


Fig. 29.

Fig. 30.

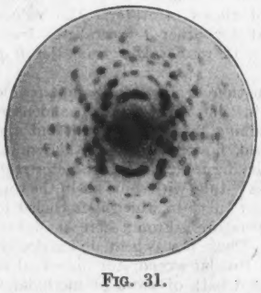


Fig. 31.

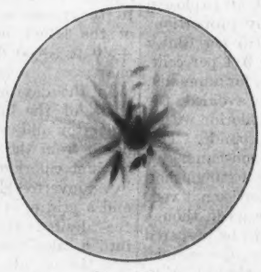


Fig. 32.

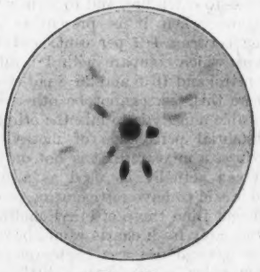


Fig. 33.

* Engineering, December 7, 1917, page 594.

24 and by Figs. 25 to 29, and others. When the number of crystallites in the field is increased, the number of dots increases and the pattern becomes complex. When the metal is stressed, the number of dots remains unchanged, but their appearances and relative positions undergo changes. That indicates that stress need not cause—and did not in his case, cause—any breaking-up of individual crystals into smaller units. There must be a change of the atomic distribution in the space-lattice itself, and that distortion must be progressive. In that respect Czochralski differs from others who, relying mostly upon other experimental methods, thought that the small pattern changes actually observed in stress experiments might be accounted for by slight defects in the crystals and apparatus. Czochralski has attempted to estimate the extent to which the local stress would affect the number of unit cells of a specimen. When he pricked his aluminium foil with a steel needle, perhaps one out of 800 unit cells was directly affected. In the Brinell tests the foil distinctly showed bending on the lower side, and finally the whole of the material which the rays penetrated may have been more or less disturbed. The quantitative estimate was attempted in the following way. He took an aluminium foil which was not stressed (Fig. 39), he stressed another foil of the same material and obtained a star pattern, Fig. 40; he then superposed the two foils and exposed them to the rays once more; the resulting diagram, Fig. 41, looked just like what one would expect from the superposition of the two photographs. Now the thicknesses of the two foils were as 1 : 5; upon that and the intensity of the dots and of the radial lines an estimate can be based, though it will be very uncertain.

On the strength of these and other researches Czochralski maintains that the "strengthening," which cold work imparts to metals under certain conditions, cannot be ascribed to the formation of an amorphous layer, nor be explained by a "translation hypothesis," but must be attributed to a "dislocation" in the lattice structure. His translation refers to flow and slip lines. All traces of slip lines and slip planes—as he has shown by other remarkable photographs—disappear more and more as aluminium, copper, zinc, iron, &c., are rolled down, so that slipping cannot be characteristic for the main period of the flow, and all evidence of a crystalline structure which etching brings out in the specimens vanishes at the same time. But one may object that deeper etching might reveal what ordinary etching failed to disclose. We might in this connection recall the deep-etching process of A. Fry, which we illustrated on page 809 of our issue of December 16, 1921. The method has quite recently proved very useful in the identification of some bars of special steel stolen from the Krupp works; all factory marks had been ground off, but the Fry-etching showed them again.

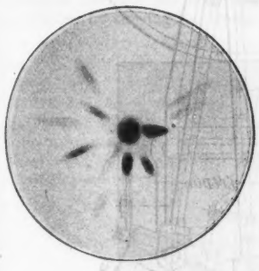


FIG. 34.

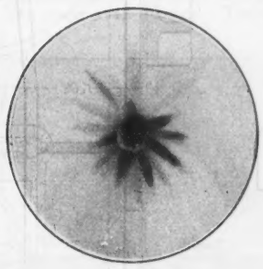


FIG. 35.

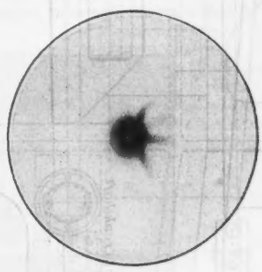


FIG. 36.

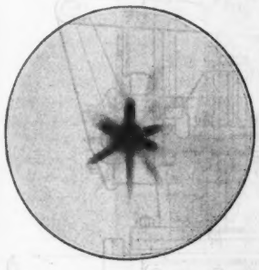


FIG. 37.

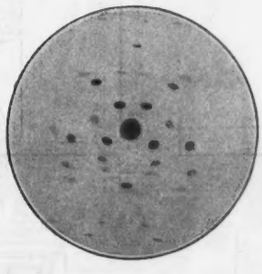


FIG. 38.

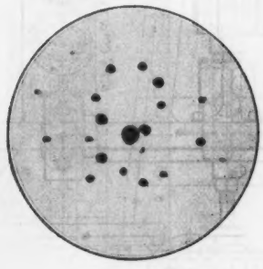


FIG. 39.

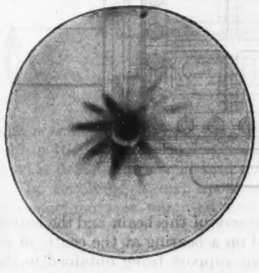


FIG. 40.

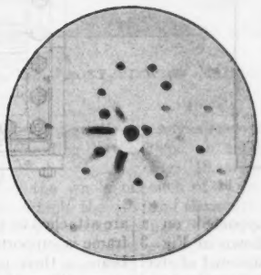


FIG. 41.

Yet the disturbance of the Laue pattern by slight stress and its advancing distortion by increased stress seem to indicate that it is the unit cell itself, the grouping of the atoms, which is gradually being distorted by stress, and that large crystals are not merely gliding over one another, or first split up into smaller units which re-orient themselves, thus becoming able to resist further stress. Some other recent experiments also seem to point to that conclusion, though the experimenters themselves interpret them in different ways. Last year A. Ono, of Kyushu University, Japan, examined by the Laue method a fine-grain copper, drawn out to wire or rolled, the wire axis being at right angles to the X-rays. The original pattern of his unstressed copper resembled our Fig. 1; the drawn specimen gave a massive star pattern in which a diameter, parallel to the direction of the pull, was prominently developed, and the angles of the star rays agreed with Ono's calculations made on the assumption that the chief crystal planes would tend to place themselves at right angles to the direction of the pull. Like Czochralski, he obtained more characteristic diagrams with rolling than with drawing his metal. Substantially Ono's conclusion is that at which F. Körber (*Zeitschrift für Elektrochemie*, July last) arrived in his experiments with aluminium by both the Laue and the Debye methods, and is in agreement with the views previously expressed by Polanyi and his collaborators who had also used the Debye method. This conclusion is that the resistance to shear can only attain its maximum value when the slip planes assume a symmetrical orientation with respect to the direction of the stress. That may be so. But sooner or later the lattice itself must be disturbed or dislocated, and the photographs we have reproduced suggest that this disturbance must set in at an early stage and must proceed gradually.

250-TON DRAGLINE EXCAVATOR.

EXCAVATING machinery of all kinds has long been a speciality of Messrs. Ruston and Hornsby, Limited, of Lincoln, whose large machine for the construction of the harbour at Takoradi was recently illustrated in our columns. This machine was of the steam-shovel type with a bucket of 3·5 cub. yards capacity designed for working in granite, and was the largest and most powerful of its kind built in this country up to that time. We are now able to illustrate an excavator of the drag-line type designed and constructed by the same firm, which is by far the largest drag-line excavator yet built in this country, or, so far as we are aware, anywhere else in the world. It has been supplied to the order of the Indian Government, for use in connection with the Sutlej irrigation scheme. Some of the channels to be cut in connection with this scheme are over 200 ft. wide and 12 ft. deep, and the material excavated from them will be deposited on the sides of the channel to form banks. Machines of the drag-line type, we may remark, are being used on practically all large irrigation and drainage works, their particular advantage being that they can excavate material from below the level upon which they stand, so that they are very useful for working in wet situations.

General views of the machine to which we are now referring are given in Figs. 1 and 2 on page 776 and in Fig. 3 on Plate XLIII, while Fig. 4 on the same Plate is a closer view of the base and the operating mechanism. The net weight of the machine is 285 tons, and its weight in working order exceeds 300 tons. Some idea of the impressive dimensions of the machine can be gathered from Fig. 1, in which a steam navvy, mounted on a caterpillar tractor, is shown below the jib of the large drag-line excavator. The navvy, we may mention, has a net weight of 22 tons and weighs 24 tons in working order, while its bucket has a capacity of $\frac{7}{8}$ cubic yard. The man standing on the upper end of the jib of the drag-line excavator should be noted as an indication of the scale of the illustration. The jib, we may mention, is 120 ft. in length, and the bucket suspended from it has a capacity of 7 to 8 cub. yards. Notwithstanding its great weight and size, the machine is under very easy control, steam clutches and brakes being fitted on all motions to facilitate the operations. A complete cycle includes the operations of digging, slewing, discharging the spoil, slewing back and lowering the bucket for the next cut, and these operations can be performed in from 45 to 55 seconds. Under ordinary working conditions, the machine can dig from 300 to 400 cub. yards of material per hour and deposit it 120 ft. from the axis of rotation or about 200 ft. from the position from which it was excavated. The machine can also be used as a crane if required, and, when employed in this way, will lift a load of 22 tons at 125 ft. radius.

The majority of our readers are doubtless familiar with the working of a drag-line excavator, but it may render the description of the construction and mechanism which we propose to give more easy to follow if we first explain the sequence of operations involved in the process of digging. For this operation, the bucket, which is suspended from the hoisting rope passing over the head of the jib to the hoisting drum, is lowered more or less vertically into the material to be excavated. It is then drawn towards the machine by the drag rope which passes through a fair lead at the bottom of the jib to the drag drum, the bucket, of course, being filled with material during the course of its travel. This operation is clearly shown in Fig. 13 on Plate XLIV. The bucket is then raised, still in the horizontal position, by the hoisting rope as shown in Fig. 1, the machine at the same time being slewed into the

MAIN ENGINE FOR 250-TON DRAGLINE EXCAVATOR.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

Fig 16.

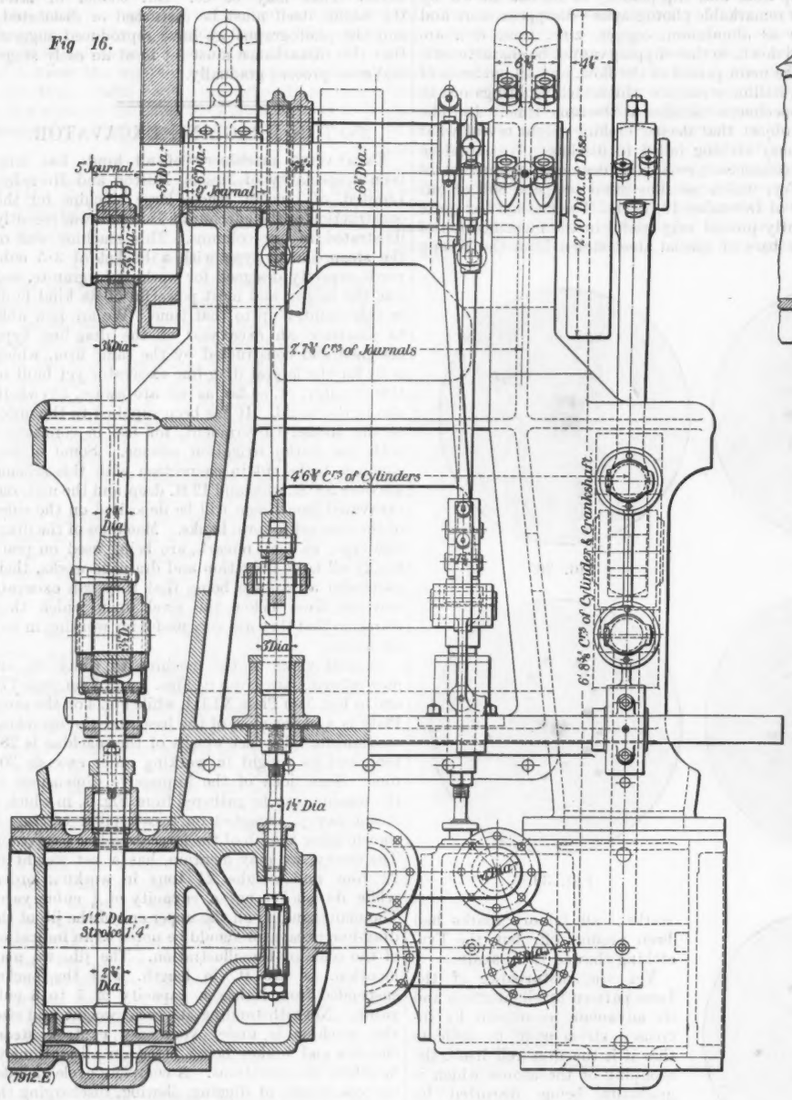
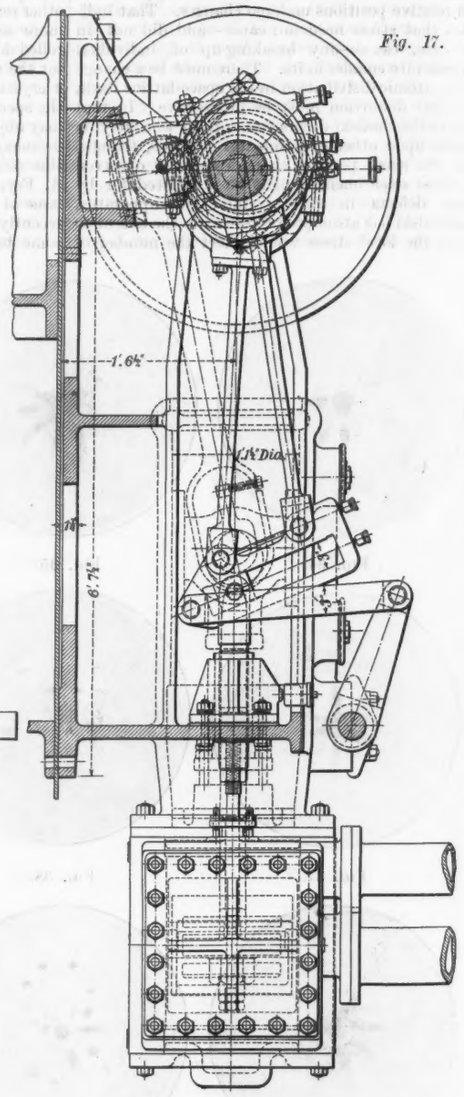


Fig. 17.



position in which it is required to dump the excavated material. The latter is then discharged by slacking off the drag rope so that the bucket falls into the vertical position with the open mouth downwards. Fig. 3, on Plate XLIII, shows the bucket in this position. It will be clear from the above that the hoisting rope has only to support the weight of the bucket and its contents, so that the jib is entirely relieved of the digging stresses. In consequence of this, the jib can be made much lighter and longer than that of a steam shovel having the same bucket capacity, and the increased cutting and discharging radius resulting from the use of the longer jib is a valuable feature of the drag-line type of excavator. All machines of the latter type manufactured by Messrs. Ruston and Hornsby are provided with travelling motion and derricking gear in addition to the hoisting and slewing motions already referred to.

The general arrangement of the machine is shown by the elevation reproduced in Figs. 5 and 6, on Plate XLIV, the jib being shown separately in the former and being drawn to a rather smaller scale in order to economise space. The arrangement of the hoisting, derricking and drag ropes can easily be followed in these illustrations without explanation. The sheaves, over which the two first-mentioned ropes pass, are supported on a double "A" frame most clearly shown in Fig 3 on Plate XLIII This frame is constructed of steel channels suitably braced and pivoted to the front of the revolving frame of the machine. The braced channel ties which support the "A" frame are also provided with pin joints at each end so that the whole structure can be lowered for convenience in transport. The jib is a light, but strong, steel structure of rectangular section built up of angles with angle bracing, its design being sufficiently shown in Fig. 5, Plate XLIV. It was made in four sections for convenience in shipment, and, as previously mentioned, is 120 ft. in length, this dimension being measured from the axis of the foot pin to the axis of the main hoisting sheave. Both pulleys at the jib head are of cast steel with bronze bushes, and the rope grooves are machined.

The whole machine is carried on a bottom frame built up of structural steel of the form illustrated in Fig. 6. This frame, which is square in plan, runs on 4 four-wheeled bogies, and measures 30 ft. between the bogie centres. To accommodate any unevenness of the ground, an equalising beam, in the form of a box girder, is provided below the bottom frame at one end. Two of the bogies are attached to the ends of this beam and the bottom frame is supported on a bearing at the centre of the beam, a three-point support being obtained in this way. When the machine is excavating, it is necessary to throw the equalising beam out of action and this is effected by means of hand-operated screw jacks, one of which is provided at each end of the beam. The arrangement is clearly shown in Fig. 7 on Plate XLIV. The design of the bogies is illustrated in Figs. 9 to 12 on the same Plate, and from these it will be seen that the load from the bottom frame, or the equalising beam, is transmitted through a spherical seating to a lever and through this to two bearings on one axle and one bearing on the other axle. This arrangement also constitutes a three-point suspension and serves to transmit the load equally to all the wheels. The latter are of the double-flange type measuring 2 ft. 5½ in. in diameter on the treads. The distance between the centres of each pair of running rails is 3 ft. 5½ in. and that between the centres of the axles is 3 ft. 11½ in. The axles, it will be noticed, are tied together at the inner ends by a pair of steel rods. It should also be mentioned that the pedestals which transmit the load from the bottom frame directly on to the bogies are each stayed by two raking struts, while similar struts, with pin-jointed connections, are employed.

to secure the ends of the equalising beam. These struts are shown in most of the photographic illustrations, but their arrangement can be seen most clearly in Fig. 4 on Plate XLIII.

For travelling the machine, power is transmitted from the main engine through bevel gearing to a vertical shaft passing through the centre of the bottom frame and driving two horizontal shafts as shown in Fig. 6. The outer ends of these shafts carry sprocket wheels on which run link chains connected to sprocket wheels on a lay shaft on each of the bogies, while a pinion on one end of the lay shaft gears with a spur wheel keyed to each axle. The arrangement of the gearing on the bogies is clearly shown in Figs. 9 and 10 on Plate XLIV. It will be obvious that the whole of the 16 wheels on which the machine is supported are driving wheels. The bogies are capable of swivelling on the spherical seatings, above referred to, so that a change in the direction of travel of the machine can be effected by slewing the track. The power available is sufficient to propel the machine up a gradient of 1 in 10 and the normal speed of travelling on the level is 0·875 mile per hour.

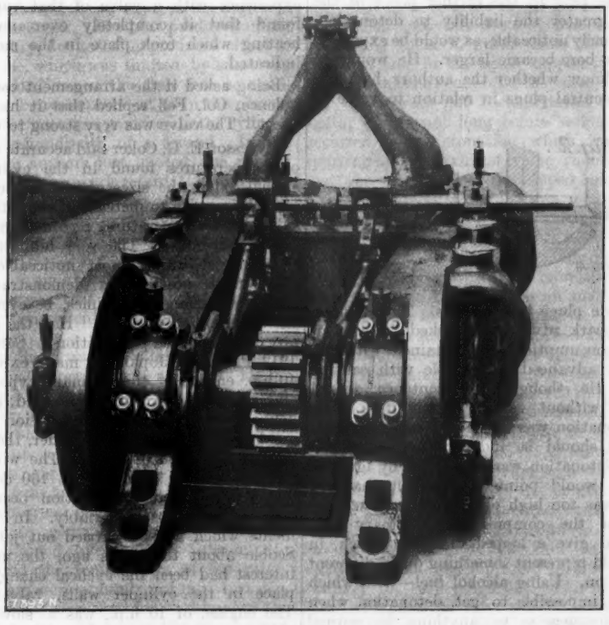


FIG. 18. FRONT VIEW OF MAIN ENGINE.

The revolving frame, upon which the whole of the machinery is mounted and to which the jib is hinged, is of steel construction and consists of four longitudinal members connected by cross girders and separators. It is supported, as shown in Fig. 6, Plate XLIV, on double-flanged rollers measuring 11¼ in. in diameter on the treads and running between two rails bent to form a circular track 30 ft. in diameter. One of the rails is fixed to the bottom framing and the other to the revolving frame. To follow the general arrangement of the machinery reference should be made to Fig. 6 from which it will be seen that the boiler is mounted transversely at the rear end of the revolving frame. The boiler itself is illustrated separately in Fig. 14, on Plate XLV. It is of the locomotive type, arranged for side firing, and has an overall length of 18 ft., while the diameter of the barrel is 6 ft. 4 in. It has been built in accordance with the Board of Trade regulations for a working pressure of 125 lb. per square inch, and has been tested hydraulically to a pressure of 225 lb. per square inch. The heating surface of the boiler is 1,380 sq. ft., and the grate area is 48 sq. ft. The small boiler shown in the foreground of Fig. 14 was made by Messrs. Ruston and Hornsby for a steam wagon, and has been included in the illustration so that its size may be contrasted with that of the boiler for the excavator. Beneath the boiler, space is provided for stowing 40 tons of pig-iron or other suitable ballast, and close to this are feed-water tanks having a capacity of 2,750 gallons. The tanks, it may be mentioned, can be filled while the machine is in operation, a water pipe, with packed swivelling joints, passing up through the axis of rotation of the revolving frame for this purpose. The coal bunker shown in Fig. 2 on page 776 and in Fig. 3 on Plate XLIII, is capable of holding 4 tons, and a small steam-driven hoist is provided for filling it from the ground level.

The machine is provided with five motions, viz., digging, hoisting, travelling, derricking and slewing, and, of these, the first four are operated by the main engine; a smaller auxiliary engine is provided for the slewing gear. Fig. 15 on Plate XLV, shows a part of the main engine and the hoisting and digging drums, while Figs. 16 and 17 on page 764 are, respectively, a plan and side elevation of the main engine. The engine, although drawn vertically for convenience in Figs. 16 and 17, is of the horizontal type as shown in the photographic illustration, Fig. 18 annexed. It has two simple cylinders each of 14 in. bore with a piston stroke of 16 in. and these drive two balanced disc cranks, the crank-pins of which are set at an angle of 90 deg. Stephenson's link motion is employed and all wearing parts of the gear are hardened and ground, and the cross-heads are fitted with renewable cast-iron slippers. Without describing the design in detail, it will be evident from an inspection of the drawings reproduced in Figs. 16 and 17, that it is of a simple and substantial character suitable in every way to the heavy duty imposed upon the machine. When running at 150 r.p.m. the engine is capable of developing 340 indicated horse-power. All steam and exhaust connections are of weldless steel tubing, with flanged joints screwed and welded to withstand the vibration to which they are necessarily subjected in working.

The gearing, by means of which the various motions are effected, we shall describe in a later issue, but we may now refer to the fair lead for the digging rope shown in Fig. 8, on Plate XLIV. This comprises two double-flanged rollers running on vertical axles mounted in a heavy steel casting which is bolted to the front of the revolving frame and also carries the jib foot pin. To the main casting is pivoted another steel casting carrying two sheaves placed edge to edge one above the other and rotating in a vertical plane. The digging rope passes first between the two vertical sheaves and then between the two horizontal rollers, the effect of the arrangement being to lead the rope directly on to the digging drum, irrespective of the direction of travel of the bucket and of the inclination of the ground over which it is being drawn. The rope guards fitted to the swivelling casting carrying the vertical sheaves are renewable.

As shown in the general views of the excavator reproduced in Figs. 1 and 2 on page 776 and in Figs. 3 and 4 on Plate XLIII, a steel framework erected on the revolving frame supports a corrugated-iron roof which completely covers the boiler and machinery. The roof is lined with tongued and grooved boards with an air-space of 3 in. left between the lining and the roofing sheets. Although not in position at the time the photographs from which Figs. 1 to 4 have been reproduced were taken, the sides will also be closed in with tongued and grooved boarding with suitable doors for access and with windows arranged to allow the driver an uninterrupted view of all operations. The whole of the operating levers, it may be mentioned, are located at the front of the revolving frame on the left-hand side, as is best shown in Fig. 4, and the driver can reach any of the levers without leaving the seat provided for him.

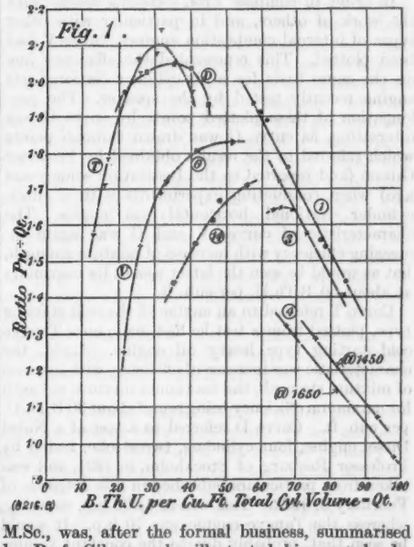
(To be continued.)

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the above Institution was held on Friday last, the 14th inst., at Storey's Gate, Westminster, at 6 p.m., the President, Sir John Dewrance, occupying the chair.

EXHAUST VALVE AND CYLINDER-HEAD TEMPERATURES IN PETROL ENGINES.

A paper on "Exhaust Valve and Cylinder-head Temperatures in High Speed Petrol Engines," by Prof. A. H. Gibson, D.Sc., and H. Wright Baker



M.Sc., was, after the formal business, summarised by Prof. Gibson, who illustrated his remarks by lantern slides of a number of the diagrams given therein. We commence to reprint this paper in the current issue (*see* page 785).

The discussion was opened by Mr. W. A. Tookey, who referred to the diagram Fig. 1 herewith, saying that this chart was based primarily upon mixture strength in terms of heat units per cub. ft. of total cylinder contents. With a knowledge of the B.Th.U. per lb. of fuel, the amount of fuel used per hour, the number of working cycles and the dimensions of the cylinder, it was easy to express the mixture strength in terms of so many B.Th.U. contained in one cub. ft. of total cylinder volume, that is, piston displacement plus clearance. This was the horizontal scale of the chart. The vertical scale was the ratio between pressures developed by the combustion of mixture within the engine cylinder and the mixture strength as above explained. The pressure was in lb. per sq. in., and when divided by the strength of mixture gave a factor of efficiency

on the basis of so many lb. of mean pressure developed for the number of B.Th.U. contained in a cub. ft. of working mixture. Comparison of test results on this factor value enabled the performance of all kinds of internal combustion engines to be compared on a standard basis, as it provided for cylinder dimensions, compression volume ratios and all other variables.

Dealing with the curves on the chart, the straight line marked 1 represented the data given in Table I of Prof. Gibson's paper. It would be seen that all the test results followed a straight line law and that the strength of mixture being used in this particular series of trials ranged from about 60 to 90 B.Th.U. per cub. ft.; the efficiency falling off with the higher mixture strengths. The curve marked 3 referred to the data given in Table 3 of Prof. Gibson's paper. It would be seen that it ran parallel to the curve of Table 1, except for three peculiar tests, and the reason for this was explained in Prof. Gibson's paper as being due to the position of a sparking plug. Reference to the paper itself would make this clear.

The curve marked 14 was plotted from information deduced from Fig. 14 of the paper and related to the performance of the engine then run under test at 1,680 r.p.m. with a volume ratio of 4·92. This particular test had been selected because in Professor Gibson's paper five points were given, enabling the curve to be plotted with greater accuracy. This test was made with water-cooled cylinders, whereas those noted by curves 1 and 3 referred to air-cooled cylinders. The peculiarity of the curve 14 was that with increasing mixture strengths efficiencies were increased; the converse of curves 1 and 3. Curve 4 was taken from Table 4, and as there indicated it would appear that other things being equal the speed at which the engine was operated had something to do with the relative efficiency when compared on the basis of the mean strength of mixture.

In order to compare Prof. Gibson's results with the work of others, and in particular with other types of internal combustion engines, curve V had been plotted. This represented the efficiency line on the same basis for a six-cylinder National gas engine recently tested by the speaker. The prolongation of these plotted points by curve G was interesting, as curve G was drawn through points which referred to the results obtained by Professor Gibson (and reported to the Institution some years ago) when conducting experiments with a single cylinder National horizontal gas engine. The characteristic of curves V and G was again increasing efficiency with increase of mixture strength, but as would be seen the latter was at its maximum at about 50 B.Th.U. per cub. ft.

Curve T referred to an engine of the cold starting type, plotted from a test he had made on a Tangye cold-starting type heavy oil engine. Again, the characteristic was increase of efficiency with increase of mixture strength, the maximum mixture strength for maximum efficiency being round about 30 B.Th.U. per cub. ft. Curve D referred to a test of a Nobel Diesel engine, four cylinders, two-stroke, tested by Professor Rosburg, of Stockholm, in 1921, and was taken from particulars published in *The Engineer* of February 3, 1922. This was of 1,000 h.p. capacity, whereas the Tangye engine was 70 h.p. It would be seen that, probably due to the constant volume cycle rather than constant pressure cycle, the rate of change in the efficiency curve was much less, indicating that the chief difference between the two cycles, namely, the relative timing of fuel injection, did affect the efficiency very materially at loads other than full load.

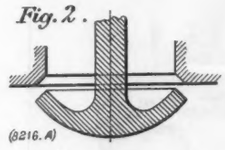
It would be realised that this efficiency factor based on mean pressure on the brake horse-power basis did not represent the true ratio of work produced per heat unit contained in the mixture. This could only be obtained from a knowledge of the mean pressures on the indicated horse-power basis, and it was, no doubt, on this account that the maximum point on curve D was lower than the maximum point on curve T, as undoubtedly the resistances of the Diesel type with air compressor with more than the resistances of the cold-starting Tangye engine, and it could therefore be expected that the ratio Pm ÷ Qt would be more nearly equivalent than the ratio Pn ÷ Qt.

He considered that this chart indicated the usefulness of this method of comparison, and he expressed the hope that those engaged on research work on internal combustion engines might adopt some such standard basis of comparison so as to get away from air-petrol and other ratios which were really unscientific expressions for mixture strength and useless for comparative purposes even with engines of similar type.

Lieut.-Col. L. F. R. Fell, D.S.O., said that he had carried out numerous experiments in connection with the effect of the position of the sparking plug on exhaust valve temperature, and had found, as the authors claimed, that the placing of the plug opposite the exhaust valve was prone to produce pre-ignition. He had, at the present time, an engine in which the plugs were fitted on either side of the cylinder and also centrally on the head. The plug on the inlet side, *i.e.*, opposite the exhaust, definitely gave a drop in r.p.m. when switched on.

The central position was by far the best. Mr. Ricardo had stated that the greater the distance from the plug to the further point of the cylinder, the greater the liability to detonation. That was extremely noticeable, as would be expected, as the cylinder bore became larger. He would be interested to know whether the authors had any experience of central plugs in relation to value as

Fig. 2.



against the side plugs in the walls. The authors, dealing with spark advance, remarked "the minimum petrol consumptions are obtained with the spark as fully advanced as possible with causing detonation." He thought the sentence should really read "without causing pre-ignition." In his view, detonation was dependent on flame temperature, and should be independent of ignition advance; if detonation were produced by ignition advance, this would point to the fact that the compression was too high or the type of fuel was unsuitable for the compression. Ordinary pre-ignition would give a looped diagram, which, in his view, would represent something quite different from detonation. Using alcohol fuel—with which it was almost impossible to get detonation when raising the compression to anything in normal practice—it had been found that the compression ratio could be raised by as much as 7 : 1, and the only effect would be that when the ignition was advanced beyond a certain point pre-ignition would set in; the loop diagram was produced before detonation was produced.

With regard to the inclined plug, he would like to know the exact position of the plug, said to account for the drop in horse-power; it appeared a small cause to produce such a large effect. The authors had submitted a very interesting table showing the effect of jacket water temperature on cylinder-head temperature. It would appear that the comparatively small effect on the cylinder head temperature of an increase in the jacket-water temperature, and the difference in temperature between the cylinder head and the cooling water at its outlet from the cylinder were both due to the latent heat of evaporation allowing heat to be extracted at a high rate, due to the formation of steam without actually increasing the temperature. Further, it was stated (c) that the great reduction in valve temperature, accompanying a reduction in cooling-water temperature, was only to a small extent due to the direct cooling of the valve seat. Might not that possibly be due to the steam formation round the valve seats impeding the circulation of the water.

Mr. Ricardo had also carried out very interesting experiments on the utilisation of oil as the cooling medium in place of water. Results indicated that oil was entirely unsuitable, due to the fact that if local overheating occurred, as it certainly did round the valve seat, a deposit was formed, which, of course, further increased the tendency to overheat. It was found also that, on analysis of the oil at the end of the test, certain fractions were completely absent. As these boiled out at something over 200 deg. C., it showed that there must have been some very hot spots inside the cylinder. The power of the engine was reduced by something like 15 per cent. with oil-cooling tests.

With regard to valve design, the ordinary type of tulip valve mentioned had certain serious disadvantages and was being slowly superseded. It had a large surface exposed to the heat of combustion, and there was a constriction which was responsible for the very severe heating which took place between the seat and the stem. The actual area through which the gases had to pass when the valve was partly open was, owing to the shape of the curve of the valve, less than the area of the seat used in calculation. To overcome this they had produced another type of valve, illustrated in Fig. 2 herewith. In this case there was absolutely no constriction at all. Had the authors had any experience with a valve of that type? He had found that it completely overcame the severe heating which took place in the manner he had indicated.

Being asked if the arrangement caused any turbulence, Col. Fell replied that it had the reverse effect. The valve was very strong to resist collapse.

Professor E. G. Coker said accurate measurements of temperatures found in the cylinder were of special value, the sizes of internal-combustion engines being sure to increase in the future. He considered the temperatures recorded in the paper to be very accurate. The very high temperature of the exhaust was a most noticeable aspect. He thought it possible to demonstrate that that temperature might, at times, be even higher than the authors had recorded. Had the authors found any difficulty with pre-ignition? Somewhen about 1912 Professor Hopkinson made experiments on a 40-h.p. engine of the ordinary type, water-cooled and running at a fairly low speed, and had tried deliberately to produce pre-ignition by putting a good stout wire into the cylinder, the end of which was in the form of bulb. The wire was heated electrically, and round about 750 deg. C. (or 700 deg. C.) sufficient pre-ignition occurred to stop the engine, almost invariably. In certain experiments which he had carried out jointly with Dr. Scoble about ten years ago, the aspect of chief interest had been the cyclical changes which took place in the cylinder walls, valves and piston. The engine, of 10 h.p., was a slow-speed engine (240 r.p.m.), water cooled, and had the usual gear of a National gas engine of that time. The temperature of explosion was generally between 1,750 and 1,850 deg. C., but in spite of that the exhaust valve temperature did not vary much more than ± 30 deg. C. The mean temperature of the exhaust valve was about 330 deg. to 390 deg. (variable mean), and the range was 30 deg. to 40 deg. on each side of the mean valve, or about 70 deg. C. As a matter of fact, for the piston the range was a good deal more, about 100 deg. C. In arranging their thermo-couples they bored out the valve head and screwed in a plug, which was finished off flush, the thickness left being a diaphragm about $\frac{1}{100}$ in. thick. They attached a wrought iron wire to this little diaphragm, while the other wire was attached about $\frac{3}{8}$ in. further back. The interior was filled up with insulating material. They were able to follow the cycle changes in the very thin disc. If instead of having both terminals of the thermo-couple in the valve one was coupled to a part outside, a mean temperature could be quite easily obtained; this mean temperature was, naturally, lower than the top temperature. He would have expected that instead of getting a temperature of 840 deg. (actually obtained), Professor Gibson would have probably had, at one instant of the stroke, the still higher temperature of probably 900 deg. C.

Professor W. E. Dalby was the next speaker. He remarked that the authors had clearly stated at the outset their intention of making the temperature of the exhaust valve an independent variable, and had then indicated the dependent variables which were going to be brought into comparison

with this. Some of the dependent variables were not quite independent of one another, but that fact did not affect the results, because estimates could be formed of how they depended one upon the other in relation to the valve temperature.

He thought it would be agreed that the problem was one of heat transmission; a large quantity of heat was suddenly produced inside the cylinder, and flowed thence across the walls to the outside in a very complicated path. Every piece of metal in the path took up, as Professor Coker had indicated, a cyclical variation of temperature superposed upon the mean temperature. What the cyclical variation was, it was difficult to say; the mean temperature could be measured. He would ask whether the knowledge of the exhaust-valve temperature would make it possible to work backwards and assist in designing an engine to give the best results; he thought it would.

The authors had definitely indicated that the highest temperature of the exhaust valve was obtained with a weak mixture and a full throttle, with high temperature of the water jacket and with retardation of the spark. The heat produced in the cylinder could vary, due to being produced either in a very short time, which was limited by what was called "detonation," when the time was so small that it could not be measured—or, as in the normal working, when the heat was produced in the cylinder in about one-fivehundredth of a second. In the conditions of the authors just quoted, the normal time was lengthened by spark retardation and weak mixture. It seemed to him that the highest temperature reached in the explosion, under these conditions, was lower than the highest temperature which would be reached either momentarily, on detonation, or on an abnormally quick explosion. The consequence was that the temperature difference—and the consequent heat flow outwards—would be smaller. As a result, when the exhaust valve was open there was probably more heat to escape by that path, resulting in a slightly higher temperature in the exhaust valve. He had himself recently measured temperatures of the exhaust in a four-cylinder engine of about 20 h.p., running at about 1,400 revs. The exhaust gas temperature was about 1,700 deg. C., measured just after the gas had passed the valve. The engine was a motor-car engine. The temperatures measured were in general agreement with the temperatures obtained by Professor Gibson. He had not measured the temperature of the valve. In the paper there were a number of indicator diagrams which had not been used for working out the indicated horse-power. He would like to ask what type of indicator was used, and whether the indicated horse-power data, in the authors' opinion, formed a valuable addition to the experiments?

Mr. E. B. Wood remarked that, although he knew more or less what to expect, he was surprised to find that both the exhaust valve and cylinder head of an ordinary motor-car type of engine attained the temperatures given in the paper. Considering that the spontaneous ignition temperature of petrol was in the neighbourhood of 300 deg. C., it was not surprising that an engine was susceptible to small differences of combustion chamber shape and sparking plug position, with a comparatively large area of combustion chamber wall at 750 deg. C. The inlet valve also might well reach a temperature of 400 deg. C. to 500 deg. C. In Fig. 13 in the paper the valve temperature was shown to be closely proportional to the amount of petrol used per unit of time, while the authors stated that the valve temperature was substantially constant for the same output at different compression ratios. It might therefore be assumed that the temperatures actually rose with increasing compression ratios. He wished the authors had investigated a wider range of compression ratios, and thus have thrown direct light on Ricardo's observation that the volumetric efficiency decreased with the compression ratio, the drop being particularly noticeable between ratios 6 : 1 and 7 : 1. Speaking from memory, the figures were for a 4 : 1 ratio about 79 per cent.; 5 : 1, 76 per cent.; 6 : 1, 72 per cent.; and 7 : 1, 65 per cent.

With regard to water-cooled valves, a point of interest was the lower temperature of the cylinder head and piston, in spite of the increased output. He thought that the poppet valve type of engine had about reached its limit. Most makers seemed to think that the poppet valve was absolutely essential. He thought some development of the sleeve valve type ought to follow. Supposing Mr. Ricardo's figure of 65 per cent. to be right—the throttle was not, so far as he understood, fully open—the temperature at the closing of the inlet valve would be something about 164 deg. C. For a sleeve-valve type, to use a conventional term, the corresponding temperature would be about 45 deg. C. What other result than detonation could be expected if a start were made with a temperature of something like 160 deg. with compression at a ratio of 7 : 1, taking place in contact with surfaces at a temperature of 750 deg. C.?

Mr. E. R. Dolby referred to a practical incident connected with exhaust-valve temperatures coming within his experience. The engine was of much greater size than that under discussion and used producer gas. The engine had worked for a considerable period when the engineer-in-charge considered it time to grind in the exhaust valves. He took them out, but found considerable difficulty in holding them to grind them in. He therefore drilled a hole in the head, tapped it and inserted a bolt so that he could hold the valve better. When the valves were put back and the engine started again, it was not long before serious pre-ignition occurred, with detonation which resulted in the splitting of the exhaust valve chamber. In that case, the sharp edge of the tapped hole rose to such a temperature that pre-ignition resulted, and probably if the man had plugged the hole the difficulty would not have arisen.

Mr. B. B. Low spoke next. He desired to refer to the effect of valve lift. The authors had found that increasing the lift gave an increase in power and a decrease in valve temperature. Theoretically, the maximum lift of poppet valve was usually taken to be about one-quarter of the diameter of the valve port. The diameter of valve port used in the engine under discussion was about 1·425 in., and therefore the theoretical maximum lift would be about 0·36 in., but the highest lift mentioned in the paper was 0·312 in. He would ask the authors what would be the effect on the power and temperature of increasing the lift to 0·36 in., or even more. The Clarke Thomson Research had made a report to the United States National Advisory Committee for Aeronautics on "Air Flow through Poppet Valves," which was reprinted in ENGINEERING for January 10, 1919 (page 59). This report showed that the higher the valve was lifted the greater the flow of the gas, and this was true even when the theoretical maximum lift was exceeded; in fact, the greatest flow was obtained with the valve reversed, so that its head was outside the cylinder. In these experiments the gas supplied to the valve had a constant head. The greater the lift the less the obstruction to the flow of gases through the valve; hence increase of lift increased the flow. The theoretical maximum, as usually defined, was consequently merely a geometric maximum. It might be objected that increasing the lift of a valve would necessitate employing a stronger valve spring. Attempts were sometimes made to keep down the strength of the valve spring by employing a short lift; and using a rapid lift and a long dwell at full lift. Rapid lift was beneficial, but short lift and long dwell at full lift appeared to have no advantage. It was actually the fact that increasing the lift in that case would enable a weaker spring to be used.

Professor P. M. Baker appealed for more distinctive labelling of the diagrams in the paper. In places, the description did not adequately disclose plug positions. He would also have preferred the same units being used throughout. These matters would render comparisons easier to work out. Although the authors had said that the plugs were symmetrical with reference to the exhaust valve, that was not quite true of the symmetry with reference to the outside passage, and therefore perhaps to the fuel flow. The passage through which the gas passed to the valve was curved, and doubtless there would be some tendency of the flow to continue in a direct line from the inlet passage, so that the bulk of the gas would pass in to the cylinder over that part of the valve in this line. On the more sheltered side there might perhaps be a residue of exhaust gases. The position of the plug would be affected by such conditions, and that might account for some of the effects. Possibly the reason for the big difference in valve temperature fluctuation as compared with jacket water fluctuation, was that a great deal of the heat drop was at the metal surface. He thought that there was probably very little cyclic variation in the temperatures at a speed ranging from 1,500 r.p.m. to 1,800 r.p.m.; the time available for such changes was not very great.

Professor A. H. Gibson in reply, said they had not had experience with central plugs, their cylinders being comparatively small in diameter with overhead valves; in any case, there was no room to put in central plugs. In the connection Colonel Fell had referred to, the word "detonation" was used deliberately, because, under the circumstances, the first phenomena noticed was the definite pinking associated with detonation. This pinking was definite for a little time, ultimately merging into true pre-ignition; the sequence of events was first detonation ultimately growing into pre-ignition. With regard to the position of the inclined plug, there might be something in Professor Baker's suggestion that the plug might not be symmetrical with reference to the direction of the inlet gas flow. Apart from that, however, he thought that the actual effect of the plug as inclined had much to do with the results. This was particularly noticeable when the spark was retarded, when the burning was abnormally slow, whereas it was not nearly so pronounced when the spark was well advanced and the spark took place quickly.

As to the effect of water temperature on the cylinder-head temperature, Colonel Fell had suggested that this was probably due mainly to steam formation, but he was not prepared to accept that explanation, because they had had a series of thermo-couples in the water supply (just a little above the surface of the cylinder) measuring the temperature of the water. These thermo-couples (one of which was placed just over the hottest point of the cylinder) did not, except in very few cases, register a temperature so high as the boiling point of water; therefore no steam could have been formed. Professor Coker had enquired whether the authors had had any difficulty with pre-ignition. He would say, in reply, that, except in cases where the compression ratio used was very high, *i.e.*, over 5·2 : 1, pre-ignition was not noted under normal conditions so long as the spark advance was not more than about 45 deg., the reason being the high speed of the engine—about 1,800 r.p.m. The indicator available at the time of the tests was an American type—the Midgley—and although it gave results which, for comparative purposes, were quite useful and good, he would not care to trust them for quantitative work. Later, however, a Watson-Dalby indicator had been procured, and this gave excellent results at speeds as high as 2,000 r.p.m.

After a vote of thanks to the authors, the President announced that there would be an informa meeting of the Institution on Friday, January 4, at 7 o'clock, the subject being "Mechanical Methods of Boiler Firing," to be introduced by Mr. H. P. Gaze. A general meeting would be held on Friday, January 25, 1924, when there would be a lecture on the "Progress of Mechanical Engineering in the Military Services," by Major G. Le Q. Martel, D.S.O., M.C., R.E.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.—The annual exhibition held by the Physical and Optical Societies will be held on Wednesday and Thursday, January 2 and 3, 1924, at the Imperial College of Science and Technology, South Kensington, and will be open in the afternoon between 3 p.m. and 6 p.m., and in the evening from 7 p.m. till 10 p.m. On the afternoon of the 2nd prox., at 4 p.m., and on the 4th at 8 p.m. Mr. H. B. Grylls will give a lecture on "The Heape and Grylls Rapid Cinema Machine. In the evening of the first day, at 8 p.m., and at 4 p.m. on the second day, Sir Richard Paget, Bart., will give a lecture on "The Nature and Artificial Production of Human Speech (Vowel Sounds)." The lectures will be illustrated by means of experiments and lantern slides. Over fifty firms are exhibiting apparatus, and a number of demonstrations will be given. The members of a number of institutions have been invited, but tickets of admission should be obtained from the Hon. Secretary of the Physical Society, Imperial College of Science and Technology, South Kensington, S.W.7.

THE VERMOT PETROL SHUNTING LOCOMOTIVE.

CONSTRUCTED BY THE USINES DE CONSTRUCTIONS MÉCANIQUES, VILLEFRANCHE-SUR-SAÔNE.

(For Description see opposite Page.)

Fig. 1.

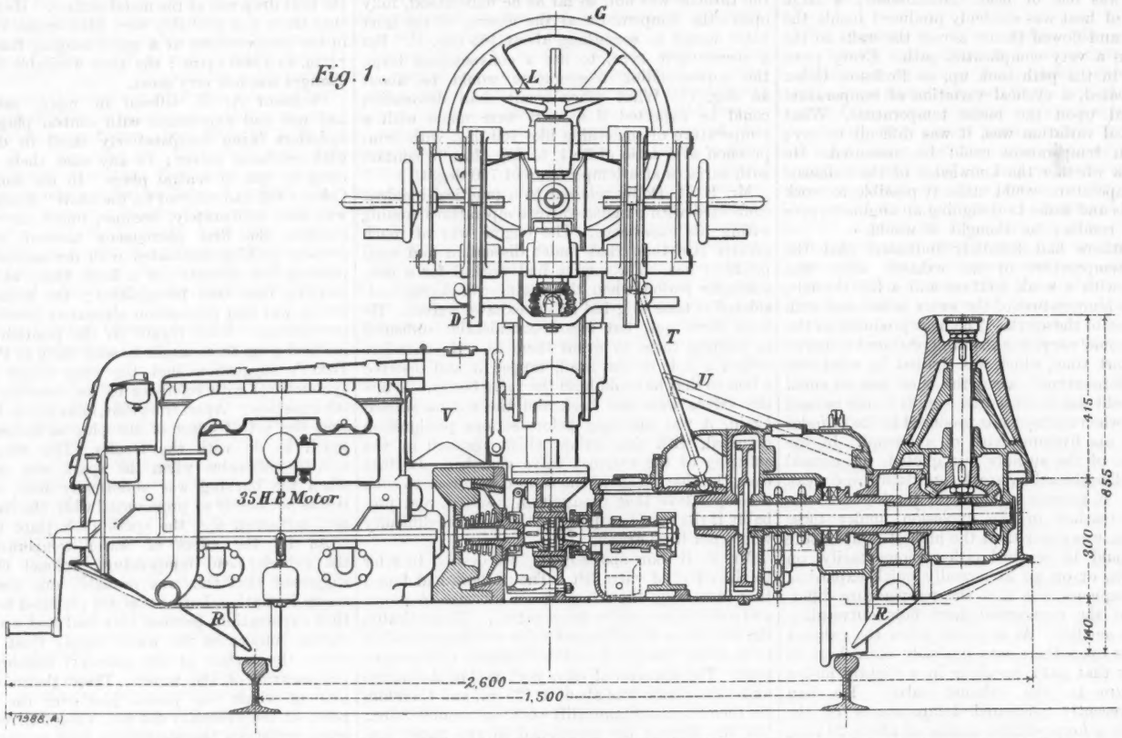


Fig. 2.

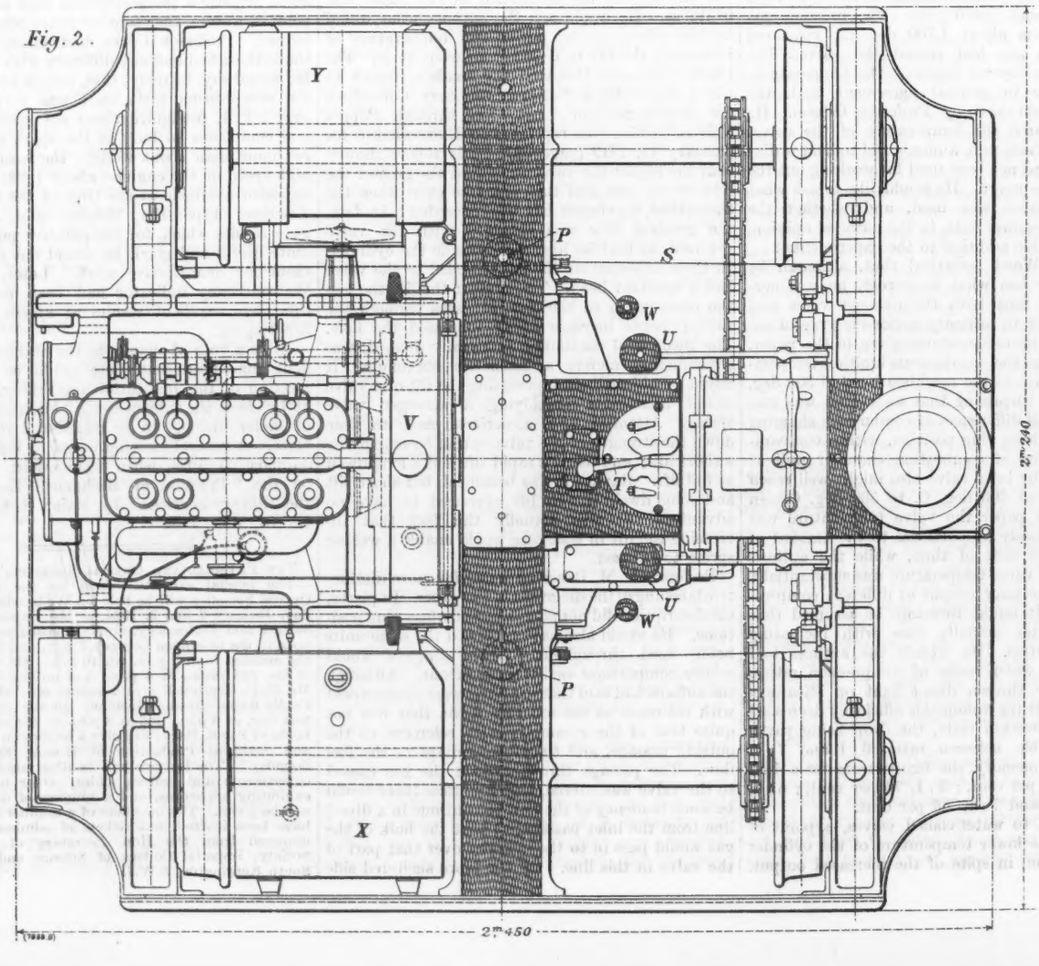


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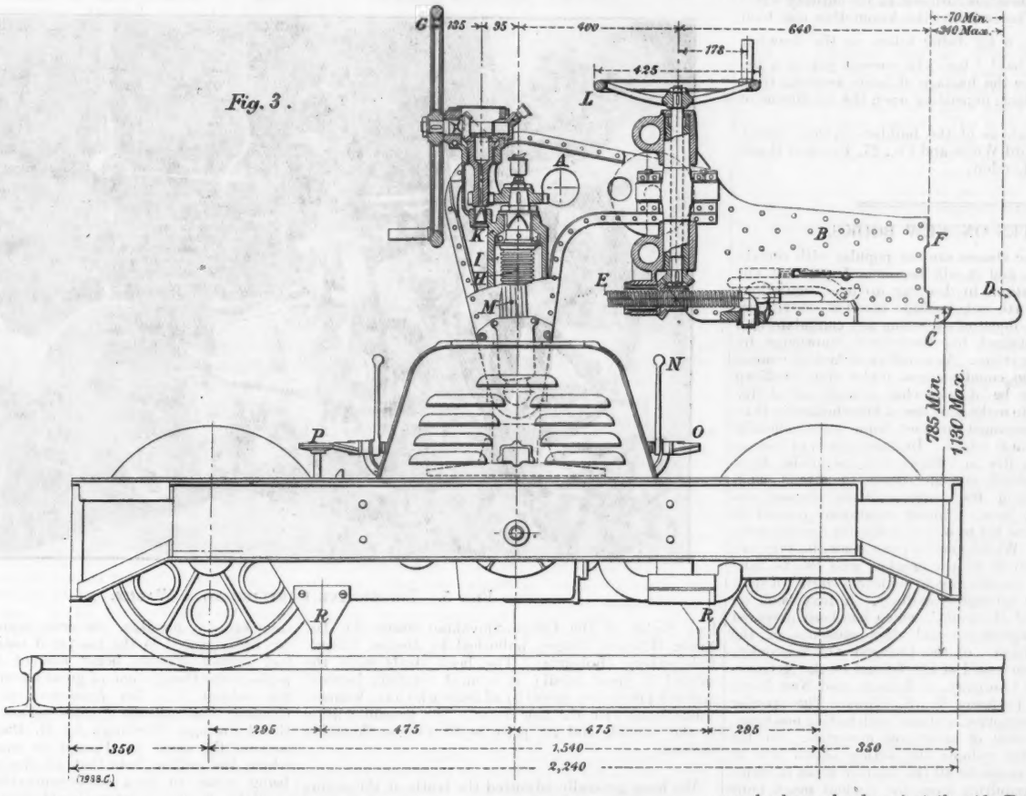
Fig. 3.



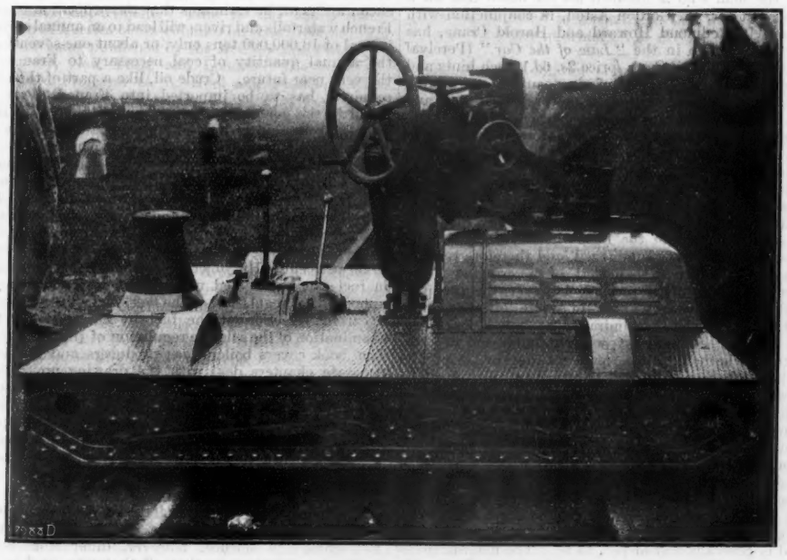


FIG. 4. GENERAL VIEW OF LOCOMOTIVE.

THE Vermot petrol locomotive, illustrated on the present and opposite pages and page 770, is one built by the Usines de Constructions Mécaniques, Villefranche-sur-Saône, for shunting operations in railway stations and on works' sidings. The locomotive is driven by a four-cylinder, 35-h.p. vertical Rochet-Schneider petrol engine, located as shown in the elevation, Fig. 1, and the plan, Fig. 2; it drives both axles by a clutch, change-speed gear, sprockets and chains (Fig. 2). The highest travelling speed attainable is 18 km. (11 miles) per hour. The petrol engine can also work a capstan on the engine platform (Figs. 1 and 2). When the locomotive brakes are set, and the engine is made to work the capstan, the latter develops a pull of 4·3 tons at a speed of 36 m. (118 ft.) per minute. The machine can in this way move a heavy load of wagons, the arrangement, it is claimed, being without the disadvantages attendant upon fixed capstans in a yard, which often require long cables and guide pulleys which decrease the hauling capacity. The device used for coupling direct to wagons is shown in Fig. 3. It consists of the double arm bracket A. B, ending in the extension C, which fits underneath the buffer beam of the first wagon to be moved. The hook D has a certain amount of play in the horizontal plane. By means of the screw E, the front end of the wagon can be drawn hard against the side F of the bracket. In order to allow the extension C to fit underneath the buffer beam of the wagon, the bracket A, B, can be lowered by operating the handwheel G, which rotates the screw H in the fixed bearing I by means of gearing; the sleeve K is furnished with roller bearings. The reverse action raises the bracket until the extension C bears underneath the buffer beam of the wagon and raises it slightly; this has the effect of transmitting to the bracket, and hence upon the centre of the shunting locomotive and upon its four wheels, a portion of the wagon load. The handwheel L operates the screw E. Notwithstanding the firm hold of the engine on the wagon, the connection is not a rigid one owing to the bracket having horizontal and vertical play. In order to deaden the shocks set up on suddenly starting to move, the bracket is mounted on the chassis in a ball and socket bearing and is maintained in position by the strong springs M. The whole of the coupling system can pivot round a vertical axis, so as to allow coupling on one side or the other of the locomotive. The locomotive can both haul and push a load. Coupling-up takes 30 seconds and uncoupling 15 seconds. The height of the extension C above the rail level can be made to vary from 785 mm. (30·9 in.) to 1,130 m. (44·5 in.). Its reach can be extended horizontally for 340 mm. (13·4 in.). The wheelbase of the engine is 1·540 m. (5 ft. 0⅝ in.). The other references to our illustrations are as follows: N, throttle lever; O, accelerator pedal; P, clutch pedals; R, sand boxes; S, cable operating the sand boxes; T, reversing and change-speed lever; U, brake pedals; V, water tank; W, pedals operating the sand boxes; X, petrol tank; Y, radiator. The locomotive has three speeds in either direction; the capstan is similarly geared.

The makers claim for this locomotive a characteristic feature which is not present in the various other engines used for a similar purpose, the power of the latter being limited by the normal adhesion of the wheels on the track, so that to obtain a high drawbar pull it is necessary to increase the weight of the engines by loading them, to the detriment of their efficiency, and increasing their cost. The Vermot locomotive weighs 4 metric tons; a portion of the load of the first wagon hauled is transferred to the centre of gravity of the locomotive and may increase to 10 tons the load distributed on its four wheels. Reckoning upon a drawbar pull of ⅓th of the weight available for adhesion, the drawbar pull may reach as much as

1·650 metric ton, which may be increased to 2 metric tons if sanding be resorted to. On the other hand, the petrol engine is only sufficiently powerful to transmit to the wheels a tractive effort of 1·450 metric ton, which is lower than the drawbar pull of 1·650 metric ton and, therefore, utilised in its entirety without skidding. Theoretically, the locomotive can haul $\frac{1450}{6}$ or 240 tons, 6 kg. being taken as the drawbar pull required to haul 1 ton. In current practice, the builders guarantee the haulage of loads weighing from 150 tons to 180 tons, depending upon the conditions of the wagons.

The representatives of the builders in this country are Messrs. Clifford White and Co., 27, Pavilion Road, Knightsbridge, London.

NOTES ON NEW BOOKS.

Correspondence classes are not popular with certain vested interests, and it will be remembered that our Board of Education, in drawing up new regulations for the Whitworth scholarships inserted provisions, with the special object of excluding any candidate who might have obtained his theoretical knowledge by means of private study. As a matter of fact, of course, any student who could succeed under this handicap would obviously be of somewhat exceptional ability and more likely to make good use of his scholarship than the carefully crammed product from some officially recognised technical school. In many cases, of course, young engineers live in villages and are unable from purely geographical considerations to attend such schools. To them the correspondence classes are a very distinct boon. Similar conditions prevail in America and have led to a very extensive development of the system. Whilst good for the students, they are not without benefit to the teacher who has to take special pains in the attempt to achieve a clarity of style that shall defy misunderstandings. A text book on the "*Strength of Materials*," which has been prepared for the "correspondence and class students of the Extension Division" of the University of Wisconsin, has recently been issued at 11*s.* 3*d.* net by the McGraw-Hill Publishing Company, of London, and New York. The author is Professor W. E. Wines. The opening chapters are descriptive, and deal with testing machines, and the properties of structural materials. In the remainder of the volume the author shows how to calculate the stresses in all the simpler types of structure, without requiring from the student much more than a knowledge of arithmetic. We believe there is not an integral in the book, though in dealing with moments of inertia, it has been found necessary to introduce the recognised sign of summation. Where Greek letters are used, as happens occasionally, the author explains their pronunciation in a footnote. The volume will undoubtedly prove very useful to the class of student for whom it is designed.

"*Die Walzwerke, Einrichtung und Betrieb*" (Rolling Mills; their Installation and Working), by A. Holverscheid, an engineer of Aachen, is one of the useful small publications of the Sammlung Göeschen (Berlin and Leipzig: Walter de Gruyter and Co.; price 1*s.*) which we have repeatedly noticed. One can not expect much of a small book of 143 pages; but there are nearly as many illustrations (125) as pages, and the treatment is technical throughout.

The advocates of the decimal system of weights and measures often lay stress on the difficulties attending calculations made with our native irrational system. No doubt the professional computer does find a drawback here, but the existence of ready reckoners has pretty well abolished the trouble so far as ordinary mercantile and commercial needs are concerned. A very complete and well arranged system of tables of this kind has just been issued by Messrs. Crosby Lockwood and Son, under the title of "*Mercantile Calculation Tables.*" The price is 3*l.* 3*s.* net, and Mr. A. Kirchner is the compiler. The principal tables show the value in pounds, shillings and pence of any weight expressed in hundredweights, quarters and pounds at a given rate The book is strongly bound and clearly printed, and will undoubtedly save much time and more stress in shipping offices and counting houses.

Previous to the war the Austrian patent laws and the amendments thereto applied, as a matter of course, to Bohemia, Moravia and the other smaller territories which then formed part of the Austro-Hungarian Empire, and now constitute the Republic of Czecho-Slovakia. Since the formation of the latter Republic, these laws have been modified and others have been passed by its new rulers. The matter is dealt with in a book entitled "*Die Gesetze zum Schutze des gewerblichen Eigentums*" (Laws for the Protection of Industrial Property), which forms part of the Stiepel Law Series of the Czecho-Slovakian State—by Dr. Erwin Hüttner, Prague, published by Messrs. Stiepel, Reichenberg (Bohemia). The book deals with the subject in great detail; it is most carefully indexed and will prove very useful to all firms who have business connections with the new State. The present edition is the second, and its price is 33 Czecho-Slovakian crowns.

We have generally admitted the truth of the saying that the man who is his own lawyer has a fool for a client, but Mr. W. Gordon Aston, in conjunction with Messrs. L. Redmond Howard and Harold Crane, has ventured to give in the "*Law of the Car*" (Percival Marshall and Co., E.C. 4; price 2*s.* 6*d.*), such hints and directions for the exercise of due caution in avoiding difficulties in connection with motor locomotion, and also how to proceed when this caution has been unavailing, that the motorist or the motor vehicle operator may feel himself qualified to take his own advice in preference to inviting professional aid. It is intimated that though one may still know but little of the law, notwithstanding the efforts of the eminent barristers to instruct him, it is yet possible to know more than does the august Justice of the Peace before whom the unfortunate motorist is summoned, and therefore to be in a stronger position than that of a cringing delinquent. There is still present, however, the qualified clerk to the justices, and in spite of the information given here, admirable as much of it is, we believe the motorist who finds himself in difficulties, whether of his own making or from the fault of others, will do well to consult a solicitor. The reasons given for adopting other courses we hold to be quite untenable. It is urged, for example, that the Bench will deal more leniently with one who defends himself. Whatever value this little book has, however, consists apparently in indicating the methods of avoiding cause of offence and of suggesting instances where legal opinion is desirable. For instance, there are pitfalls to be avoided in purchasing a car on the hire system, simple as the operation is represented, and is generally considered, to be. The maxim, *caveat emptor*, applies here as it does in all matters of warranty and agreements for sale. The rights of pedestrians are carefully guarded by law and must not be overlooked. The law of assurance is one that requires close study from the motorist, and yet how few read the whole of their policy or know exactly what it contains. We have no hesitation in saying that from the information supplied, it is somewhat difficult to understand the nicety of the principles that govern Third Party Insurance. On the other hand, in such matters as Drivers' Licences, regulations of lights and general conduct on the road, the information seems valuable and concise.

Economy in fuel consumption is a problem which it is incumbent upon every nation to solve in the most complete way possible. Several Continental countries are badly placed in the matter of national sources of fuel supply—France being one of these—and the problem for them is one of great urgency. A book on the subject is "*Les Economies de Combustibles: Conduite Rationelle des Foyers*" (Fuel Economy: Rational Furnace Working), by M. Pierre Appell. It reviews the needs of France as regards fuels, and whilst the author finds that all the endeavours now being made to turn to account the water power available in the country should receive the greatest encouragement, he estimates that the utilisation of the French waterfalls and rivers will lead to an annual saving in coal of 10,000,000 tons only, or about one-seventh of the annual quantity of coal necessary to France in the very near future. Crude oil, like a part of the coal required, has to be imported into France. Peat is found in the country in limited quantities only. The same may be said of lignite, and the calorific value of both is comparatively low. Wood can hardly be thought of. The best means available in the circumstances is to devise ways for burning less coal in works and factories without decreasing their output. By improving the installations and training the staff, the coal consumption in works and factories can be decreased, according to the author, by from 20 per cent. to 30 per cent. His object is to show how this saving in fuel can be effected under these two headings by a methodical regulation of the working of heat centres, a careful selection of the fuel by gas analyses, the examination of the ash, the regulation of the air supply. The book covers boilers, gas producers and furnaces. Separate chapters deal with the drawing up of heat balance sheets, with the recording apparatus and instruments, and with the training of the staff to whom allowances would be paid on a basis to be agreed upon. The work forms part of the "Encyclopédie Léauté," and is published at the price of 17 francs by Messrs. Gauthier-Villars & Co., and Masson & Co., Paris.

In some respects physics and chemistry have been revolutionised during the past quarter of a century. Revolutions in science, however, differ from many political revolutions in that all that was good in the systems superseded is commonly conserved in the new. In fact, enormous as has been the change effected in our views as to the nature of electricity and of the atom, so much remains unchanged that the electrical engineer need never have to make any practical use of the concept of the electron, nor need the work's chemist take account of the existence of isotopes. So far as electricity in the bulk and matter in the mass are concerned, the older views work perfectly satisfactorily, and some might indeed maintain that the electron and the isotope were refinements unfit "for human nature's daily food." Nevertheless, few of us take a grossly utilitarian view of knowledge. Our curiosity requires satisfaction as well as our more material needs, and to satisfy this craving there have of late been published

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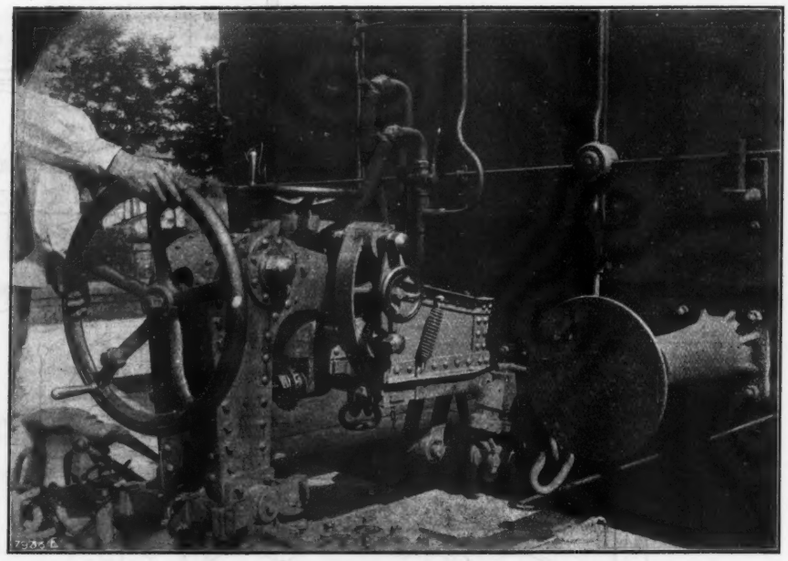


Fig. 5. Locomotive Coupling to a Wagon.

many books planned to explain to the inexpert how it is, and why it is, that physicists have been forced to abandon or modify theories which still hold good in most cases up to nearly the limits of our powers of measurement. A well-written and comprehensive little volume thus intended has been published by Messrs. Hodder and Stoughton, Limited, under the title of "*Atoms and Electrons*," the price of the book being 2*s.* 6*d.* net. The author is Mr. J. W. N. Sullivan, and in six chapters he explains, probably as clearly as it can be done without recourse to mathematics, how physicists have been led to frame conclusions as to the structure of the atom, why the doctrine of quanta was forced on us and the manner in which the electrons insisted on recognition as a fundamental constituent of matter instead of as a mere convenience for classifying certain facts of electrolysis.

Soon after Dr. Ing. Friedrich Münzinger had finished his book on the Leistungsteigerung von Grossdampfkesseln, which we noticed on page 647 of our issue of May 25 last, the National Electric Light Association of the United States published their Reports of the Prime Movers' Committee. With the aid of these reports and other information collected, Dr. Münzinger has compiled a further volume on "*Amerikanische und Deutsche Grossdampfkessel*" (Berlin: Julius Springer; price 7*s.* 9*d.*). The critical comparative study is of chief interest to German engineers whom the war and its aftermath have kept out of contact with foreign practice. But the 181 excellent diagrams and the discussions of the advantages and disadvantages of certain constructions and practices will be found generally instructive. The last section deals with the storage of steam. The 178 pages are provided with a good index.

No man nowadays can take all knowledge for his province, even in the limited field of engineering, and there has accordingly grown up in America a practice of producing text books by co-operative effort. Technical works may perhaps be divided into two classes, viz., those written to explain some new development or discovery of the author, and a much more numerous class intended to be of immediate and direct service to the practitioner. The former are naturally and properly individual efforts, and to them we must look for the advance of knowledge. The second class of text book, however, makes a much wider appeal, and since no one man has universal experience there is a distinct gain in having different sections of the subject dealt with by men who have special knowledge in that particular department. This is the characteristic feature of a series of six volumes on structural engineering now being published by the McGraw-Hill Publishing Company, New York, and London. The editors in chief are Professor G. A. Hool and Professor W. S. Kinnie, both of Wisconsin University, with whom are associated a number of bridge specialists. The third volume just published at 25*s.* net deals with "*Movable and Long-Span Steel Bridges.*" The first section, by Messrs. C. B. McCullough and P. A. Franklin, is devoted to bascule bridges, and includes a complete structural design for a double leaf bascule highway bridge. Centre-bearing swing bridges form the subject of another section, and we note that use is made here of the ingenious Williot diagram for determining the reactions. In the section dealing with continuous bridges there are descriptions of a number of successful examples. The determination of the stresses is fully dealt with and the only criticism we would make is that the author, Mr. D. B. Steinman concedes a little too much to those who oppose the type, basing his defence rather on the fact that the stresses can be found in spite of the undeterminateness of the system rather than insisting on the well-established reliability of continuous bridges in actual service. Mr. A. G. Hayden who is responsible for the excellent section on cantilever bridges seems also not entirely free from a certain fear of indeterminate stresses. Mr. D. B. Steinman also contributes the article on suspension bridges, whilst Mr. C. B. McCullough is the author of the section on arches. The work as a whole is by no means a mere collection of formulas and methods of calculating stresses. These are adequately dealt with, but much space is devoted to practical and aesthetic considerations, methods of erection and structural details. The illustrations are very numerous and well selected. Many are printed as two-page plates.

MANGANESE ORE IMPORTS TO THE UNITED STATES.—The Bureau of Foreign and Domestic Commerce reports that the manganese ore imports into the United States this year, down to October 1, were as follow, in gross tons: From Brazil, 74,098 tons; Turkey in Europe, 24,837 tons; British West Africa, 20,135 tons; British India, 13,352 tons; Russia in Europe, 11,670 tons; Argentina, 4,053 tons; Turkey in Asia, 3,005 tons; England, 1,106 tons; Panama, 400 tons; Chile, 384 tons, Germany, China, &c., 130 tons.

INDUSTRIAL NOTES.

THE following are the claims put forward by the Miners' Federation which were discussed at recent meetings between representatives of the Federation and of the Mining Association:—(1) That the ratio of profits to wages be altered from 17 to 100 below the standard and 17 to 83 above, to a constant ratio of 13 to 100 both above and below; (2) That the minimum wage be raised from 20 per cent. to 40 per cent. above the standard. (3) That further information be accorded to the miners on costs other than wages. In the course of the discussions, Mr. Evan Williams stated on behalf of the owners that in certain points their representatives had an open mind and would be prepared to recommend to the members of the Mining Association certain alterations in the Wages Agreement which would operate to the advantage of the men, provided certain concessions were made by the Federation in regard to clauses that inflicted undue hardship upon the owners in the less prosperous districts.

As regards the first claim above, the owners' representatives were prepared to consider putting forward a recommendation to the effect that the ratio be constant both above and below the standard, and that the proportion allotted to profits be something less than 17. No figure was mentioned, but it would have to be considerably higher than the 13 demanded by the Federation. As to the second claim, the owners were unable to make any concession. Mr. Evan Williams pointed out that the raising of the minimum wage to 40 per cent. above the standard would not improve the position of the lower paid men, since these were already protected by the subsistence wage. In South Wales the standard wage for surface labourers was 5*s.* 3·9*d.* per shift, and the minimum wage therefore was 6*s.* 4·8*d.*; if the minimum were raised by 40 per cent. above the standard, the figure would be 7*s.* 5·5*d.*, whereas under the subsistence wage it actually was 7*s.* 6d. Mr. Evan Williams however, suggested that the lot of the lower paid men might be sensibly improved by a redistribution of wages as between them and the higher paid men. He instanced the 14·2 per cent. advance to the piece-workers to make up for loss of earnings following the reduction in hours from 8 to 7, and suggested that this might be more equitably allocated to the lower paid men. In the matter of the third claim, Mr. Williams emphasised the fact that the items concerning which further information was asked for were such as could not be influenced in any way by the miners. Nevertheless, the owners' representatives had been favourably considering this claim and were prepared to recommend that a considerable volume of further information be given.

The principal counter proposal put forward by the owners' representatives had reference to the recoupment of standard profits sacrificed in order to pay the minimum wage, which under the award of the independent chairman were practically irrecoverable out of any future surplus. Such was not the intention of those who originally drafted the Agreement, and the owners would certainly require the revision of this restrictive interpretation as a *quid pro quo* for any concession they might be prepared to make. They realised that to recover, out of any immediately ensuing surplus, an accumulated deficit might lead to considerable hardship for the miners, and they would be prepared to consider spreading such recoupment over a period covered by several ascertainments. The owners' representatives felt that the termination of the Wages Agreement at the present time would be a national disaster. The Agreement, although far from being a perfect instrument was held to be the greatest step forward yet made in the history of British industry towards settling differences and apportioning proceeds between labour, capital and management. These considerations and not any conviction that the Agreement had hitherto operated to the advantage of the owners—who indeed had received far less under it than they were entitled to expect, had led the owners' representatives to make a further attempt to secure for the coal mining industry that peace which was so essential to national recovery.

Notwithstanding the conciliatory attitude taken up by the owners' representatives and evidenced in the above statements, the executive of the Miners' Federation decided last Saturday to recommend that a ballot vote of the men be taken on the question of giving three months' notice to terminate the Agreement, the men to be advised to vote for its termination. The main purpose of the ballot, Mr. F. Hodges explained, was to secure a larger measure of freedom to negotiate. If a living wage could not be received under the present Agreement, then such a wage would have to be secured under some other. It was not a ballot to terminate contracts of employment, but was more in the nature of a referendum on the Agreement itself. In the event of the men deciding that the Agreement be terminated, a further ballot would have to be taken, under the rules of the Federation, to determine whether or not a strike should be embarked upon.

Mr. Frank Hodges has resigned the post of secretary of the Miners' Federation, following upon his election as a Member of Parliament.

We are informed that the work of repairing the "Richard Welford," which was sunk in the Tyne early in the year and was refloated recently, has been awarded to a firm in Rotterdam at a price which is 3,000*l.* below the lowest British tender. The cost of the contract thus lost to this country being estimated to exceed 12,000*l.*, the difference, as will be noticed, is very great. It should be noted in this connection that this country is better situated—or should be—than Holland in the matter of the supply of the required materials. There is therefore evidently something amiss with our business conditions.

In the report for the current year issued by the Amalgamated Engineering Union, it is stated that the year opened with a membership of 333,123, whilst the latest figures disclose a membership of only 272,272, a decrease of 60,851. "The Executive Committee deeply regret this loss of membership, but are confident that with a revival in trade many will return to the fold." The above note on the loss of one of many ship-repairing orders hardly points to a revival in trade. The report goes on to say that for the whole of the engineering industry about 19·4 per cent. are unemployed amongst insured workpeople. The proportion of unemployed is as high as 26·1 per cent. in marine engineering, and as low as 6·6 per cent. in electrical engineering. In regard to wages, still according to the report, the average in the 10 largest districts for fitters and turners is 2*l.* 16*s.* 8½*d.* per week, or 46 per cent. above December, 1914.

The Railway Rates Tribunal has commenced, and is continuing its sittings to consider the claim made by the Mining Association—a federation of 26 associations whose affiliated collieries produce about 94 per cent. of the British coal output—for the abolition of the remaining 2*d.* flat rate per ton for the carriage of coal. The effect of this abolition would be to complete the elimination of the flat rate; two-thirds of this rate had already been abandoned by the railway companies, and it was contended that the change of circumstances which rendered it unreasonable to maintain two-thirds had made it unreasonable also, at the present date, to maintain the other third. It was stated that on every ton of steel the flat rate represented 1*s.* This country had to compete with foreign coal, European and American, and the difference which decided the contracts was often not more than 2*d.* or 3*d.* The reduction of 2*d.* per ton would help the coal industry in its fight to maintain its coal export trade. The flat rate was particularly burdensome to coal traffic, most of which was short-distance traffic. The association felt that the only hope for the coal industry, in common with industry generally in this country, was to get costs down.

Mr. R. G. Davis, general manager of Firth-Sterling Steel Company, Pittsburg, on his return from a recent trip to England has stated to *The Iron Age*, New York, that at the present time the English people are probably more heavily taxed than any other people in the world, but they seem, he added, to be meeting these conditions with optimism and approval of the efforts of their Government in re-establishing their credit and in paying their indebtedness. They are doing everything possible to economise, and it is only after close observation that one is able to note a difference in their living conditions as compared with what prevailed before the war. Mr. Davis, referring to the present-day British automobiles, said these were of light weight, low horse-power, with high speed motors, giving about 50 per cent. better economy than obtained with the average American cars. The British motor-cycle had also developed towards light weight and economy of operation. According to him it would not be surprising to see a development of the automobile in England somewhat paralleling its development in the United States. In personal conversation he found that Englishmen were in full sympathy with France and her troubles; looking, however, more broadly at the problem, they pointed out that other policies were necessary under present conditions.

SIDING RENT AND SHUNTING CHARGES ON CRIPPLED WAGONS.—It will doubtless be of considerable interest to owners of private wagons to learn that after negotiations between the Standing Joint Committee and the Railway Companies, the latter's general managers have agreed, as an experiment for twelve months, as from January 1, 1924, to adopt a commuted annual charge of 1*s.* per wagon in lieu of the present charges for shunting and siding rent on crippled wagons.

THE FOSTER STRAINMETER.

THE stresses to which composite steel structures are subjected can only be determined by observations with suitable instruments on the actual erections. In such actions as launching a ship or running it at sea, in accelerating or stopping the load on a crane, changes in stress occur which may produce considerable strains. The measurement of these strains is of great importance in obtaining an estimate of the suitability of the customary design. The Foster Instrument Company, of Letchworth, Herts., have therefore designed and placed upon the market a simple instrument, easy of adjustment and operation, to facilitate investigation of strain actions in these and similar cases. With it the strains are measured by the change of the volume of fluid necessary to fill a diaphragm box, which is supported on one part of the structure and the diaphragm of which is pressed by movement transmitted from a point further along the structure. To obtain an open scale for the measurements, the change in volume is measured with a gauge glass of narrow bore.

An actual strain meter is shown in use on a Tee in Fig. 1. At the points between which the strain is to be noted holes have been drilled and tapped for the accommodation of two studs. From one of these the measuring system is supported, and the other has a rigid rod to convey the strain movements to the flexible diaphragm. To ensure that there is no play at the studs, locknuts are used. The essential part of the instrument consists of the diaphragm box to which is connected a graduated gauge glass terminated at the top in a thistle funnel. In addition, there is provided a small plunger in a stuffing-box which can be raised or lowered by the adjusting screw at its top. This is used to vary the volume available for the fluid and thus set the height of the column to any desired part of the scale. After the instrument has been set up and the strain rod adjusted to give a slight tension on the diaphragm and then clamped in position, the initial reading is noted, or in case of necessity further adjustment is made by means of the plunger until the desired conditions are obtained. Any change in the relative positions of the two points of application will cause a change of volume of the diaphragm box and a consequent alteration of the reading of the column of fluid on the gauge glass. When the stress comes on the structure, the strains produced cause movement of the diaphragm with a consequent change of reading. Calibration constants are supplied with the instruments so that the significance of each division of the column of fluid can be obtained. An alignment rod is available for use in testing the setting of the studs. It can be passed through the holes in both the stud heads when they are accurately located. It is not always necessary to drill and tap the member of the structure under investigation as special clamps, obtainable with the instrument, may be used if the section is small. When the tests are of long duration changes of temperature may result in expansion which will interfere with the deductions but, as a statement of the temperature coefficient of the instrument is supplied by the makers, the compensation for these effects is not only possible, but simple.

Special attachments for the strainmeter were designed for use in their experimental investigations by the London and North-Eastern Railway Company, and these we are able to illustrate and describe, in this article, through the courtesy of the chief engineer of the north-eastern area, Mr. C. F. Bengough, M.Inst.C.E. The instrument, as modified for this work, is shown in Figs. 2 to 5. Each of the two clamps has two vanadium steel points on the upper jaw and a tightening screw for the lower one. On the screw a loose footstep is mounted, and thus any tendency to "walking" while the screw is tightened is prevented. The clamps were designed so that the jaws may be adjusted to take material up to 3 in. thick. A distance bar, 10 in. long, connects the two clamps by means of tapered pins which can be set in suitable positions to give a distance of 8 in. between the clamping positions, or anything less than that in steps of ½ in., down to the limiting value of 4 in. A smaller distance bar of 6 in. length is provided for use where the space available is very limited. The cylinder of the measuring instrument is connected directly to one of the clamps and has an indiarubber diaphragm held between two washers of slightly smaller diameter than the cylinder. The two holes which are used for filling the cylinder and for the connection of the graduated tube, have a plug and ferrule fitting respectively and are effectively packed with waxed cotton string. Fig. 5 shows the actual construction of this important part of the instrument.

In using the instrument after filling with diluted red Indian ink the plunger bar is withdrawn from contact with the diaphragm and the instrument is fixed to the material to be tested. The axis of the strainmeter is set parallel to the direction of the stress, which is usually attained by having the inside surfaces of the clamp hard up to the edge of the material. When the clamps have been fixed in position the distance bar is removed

THE FOSTER STRAINMETER.

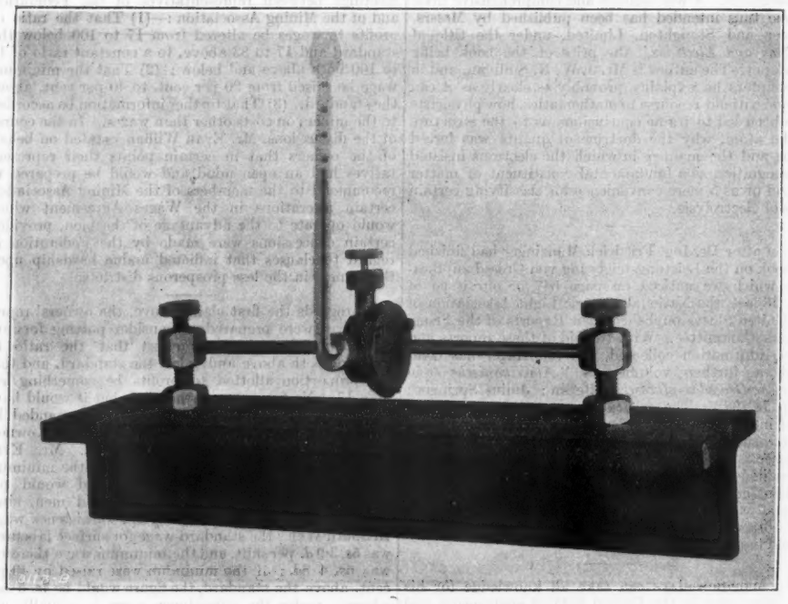
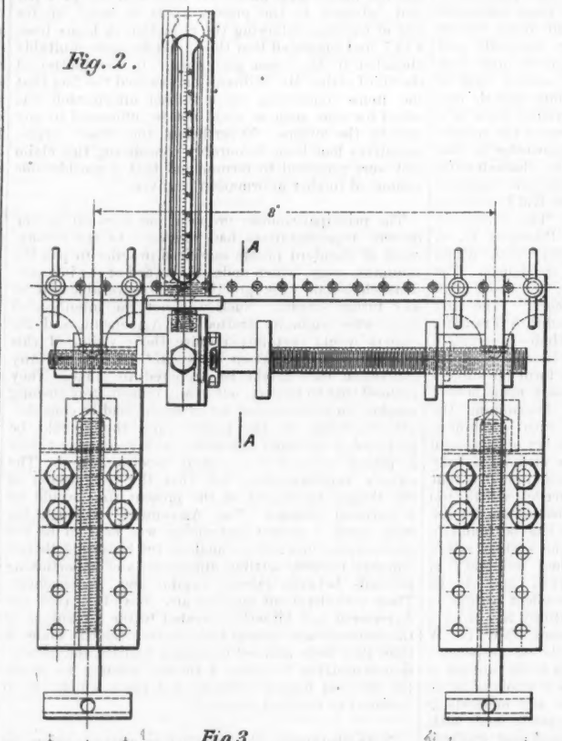
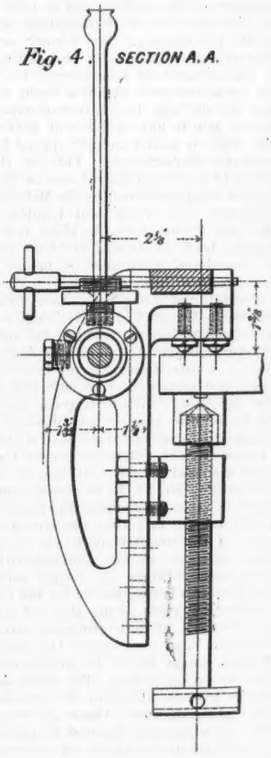
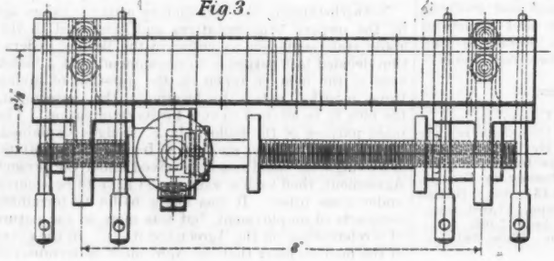
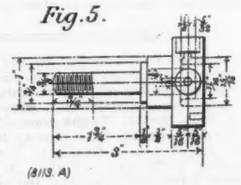


FIG. 1.









HAND TACHOGRAPH AND SPEED INDICATOR.

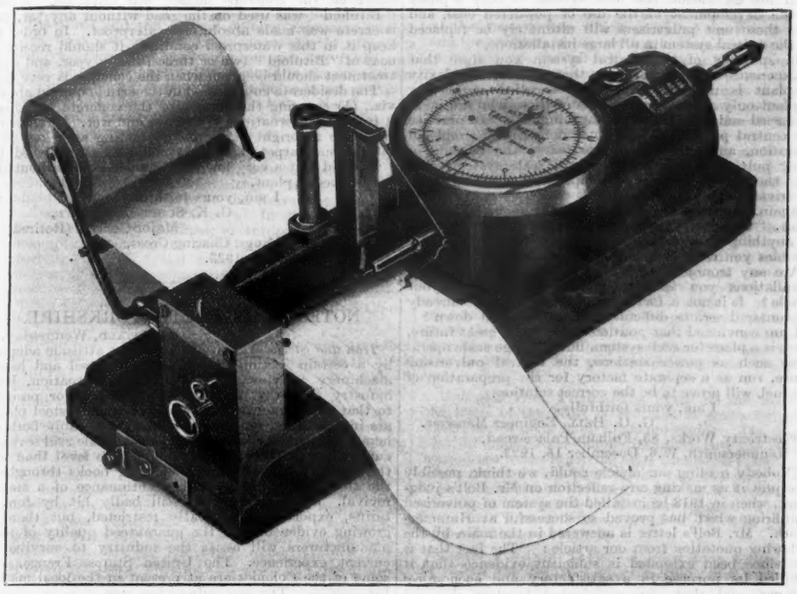


FIG. 1.

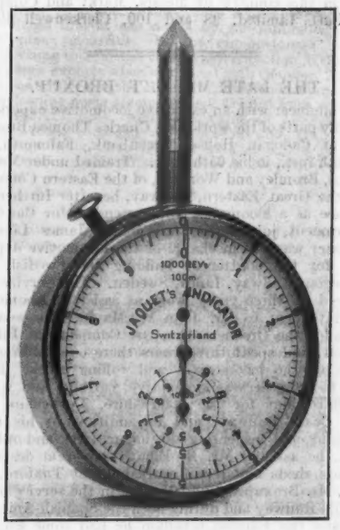


FIG. 2.

by withdrawing the taper pins. The plunger bar is then brought into contact with the diaphragm and the level of liquid set to suit the test, near the top for tensile tests and near the bottom for compression investigations. As graduated tubes of various bores may be used it is possible to measure strains over a very wide range. One of these instruments was recently tested by the National Physical Laboratory and the maximum variations in three calibrations was found not to exceed 0·00002 in., which is stated to be the limit of accuracy of the measuring machine used. The following table gives the results of the tests with three tubes of different bores :—

Tube.	Wide Bore.	Medium Bore.	Narrow Bore.
Movement in inches of the diaphragm for 50 divisions of 2 mm. each on the tube	0·00721	0·00371	0·00236
Divisions of the tube for each thousandth of an inch diaphragm movement ..	6·94	13·48	21·19
Stress in tons per square inch represented by 1 division on the tube for material having a modulus of elasticity of 13,000 tons per square inch when the instrument is set at 8 in. centres	0·2341	0·1206	0·0767

From these calibration figures it will be noted that the strainmeter has the merit of giving a large multiplication of the actual strain, and that even small stresses produce strains which are readily measurable by its use.

HAND TACHOGRAPH AND SPEED INDICATOR.

WHILE the ordinary simple speed counter suffices for a great variety of experimental and testing work in which it is only necessary to determine the average speed of rotation of an engine or machine, it is frequently desirable when more elaborate investigations have to be carried out to obtain some information as to the manner in which the speed is fluctuating. Some idea of the extent of such fluctuations can be gathered from observations of an indicating tachometer, but if precise information as to speed variations is required it is necessary to employ a recording tachograph. Several instruments of the latter type are available for the purpose, but the elaborate and expensive nature of the majority of them tends to restrict their use.

In Fig. 1 above, however, we illustrate a simple and convenient form of tachograph which is easily portable, weighing only 2¼ lb. complete, and which can be used to obtain a clear record of the speed fluctuations of a machine over a wide range, as well as for determining the rate of acceleration or deceleration after the driving power has been applied or cut off. The small speed variations of a governed machine with a fluctuating load can also be shown for testing the efficiency of the governing mechanism. As will be seen from our illustration, the instrument comprises an ordinary indicating tachometer mounted on a leather-cloth covered wooden tray, which forms the lid of a box containing the whole equipment. The tachometer mechanism is of the ordinary type and needs no description, but the reciprocating spindle which operates the hand is extended out through the metal case of the tachometer and connected with a series of multiplying levers to operate the recording pen. A roll of paper, about 2¾ in. wide, is carried on a movable holder, as shown, and fed through the instrument by means of watch mechanism contained in the small rectangular box on the left of the illustration. The paper is driven by a knurled roller against which it is pressed by a spindle carrying a number of sharp-edged discs visible in Fig. 1, and these discs also bear on an inked roller so that they mark the abscissæ on the paper as it travels through. The spacing of the discs, of course, corresponds with the main divisions on the dial of the indicator. The watch mechanism driving the paper will run for 30 minutes, and is wound up by the larger of the two knurled knobs seen on the left of the illustration. Two paper speeds are provided, the movement being about 3 mm. or 6 mm. per second, respectively, and the change from one speed to the other is effected by means of a small lever at the top of the box containing the watch mechanism.

The time is recorded by a second watch mechanism enclosed in the same box as the paper-driving mechanism and wound up by the smaller of the two knurled knobs seen in Fig. 1; both mechanisms are, of course, non-magnetic. The time-recording mechanism, which is completely independent of the paper-driving mechanism so that it is not affected by any variations in the resistance of the latter, operates a small pen which bears on the paper and is visible in the illustration in the form of a black spot on the right-hand side of the box containing the watch mechanism. This pen marks a continuous line on the paper with a slight kink at intervals of every second, or it can be arranged to mark intervals of a fifth of a second, if preferred. In either case, the time-marking appears at the top of the record, so that the rate of the speed fluctuations or the change of speed in any given time can easily be determined.

These instruments can be supplied for any speed range between 30 r.p.m. and 24,000 r.p.m., but are only stocked for the ranges 30 r.p.m. to 4,000 r.p.m. and 60 r.p.m. to 8,000 r.p.m. In either case, the range is covered in four stages, the change from one range to the other being effected by means of a sliding button on the casing near the spindle, as is usual in this class of instrument. The recording device can, of course, be used over the whole speed range, the change from one stage to the other being effected by the operator, who moves the sliding button as the pen approaches one edge or the other of the paper strip. The fact that a change in the scale has been made in the course of a record is indicated by the rapid movement of the pen across the whole width of the paper. The instruments are supplied with a set of steel and rubber points for connecting the spindle to any form of shaft centre, and also with a rubber-edged disc wheel which can be used to record surface speeds and to determine the speed of shafts of which the ends are inaccessible. The disc wheels are supplied either 6 in. or 10 cm. in circumference.

The instrument illustrated in Fig. 2 has been designed to enable the average speed of a shaft to be determined rapidly and accurately, its arrangement tending to eliminate the errors of observation that can easily be made in measurements of this kind as usually carried out with a separate counter and stop watch. The instrument comprises a simple speed counter, the starting and stopping of which is automatically controlled by a watch mechanism. In using the instrument, the spindle is placed in the centre of the shaft and when all is running smoothly, the button on the left of the spindle is depressed and released. The depression of the button winds up the watch mechanism, and its release sets the movement into operation. After running freely for 1½ sec., the counting mechanism is put into gear automatically and continues to run for exactly 6 sec., after which time it is stopped automatically. The pointer remains stationary in the position it has reached after running for 6 sec., and as the scale is graduated so as to multiply the actual revolutions of the spindle by 10, the reading gives the speed of the shaft in revolutions per minute. The scale, as shown, is very clear, and is provided with two sets of figures, one red and the other black, to enable readings to be taken in either direction of rotation. A spot seen in one illustration near the centre of the dial behind the main indicating pointer changes from red to black and *vice versâ* for the purpose of indicating which set of figures should be used. A complete revolution of the main pointer indicates a speed of 1,000 r.p.m., and as the number of complete revolutions made by the main pointer is indicated on an auxiliary dial reading from 0 to 10, the instrument can register up to 10,000 r.p.m. The main dial is divided into steps of 10 r.p.m., but the scale is a very open one so that it is quite possible to estimate the speed to within 2 r.p.m. or 3 r.p.m. Both pointers are re-set to the zero by depressing the button for the purpose of taking the next reading, but this need not be done until the spindle of the instrument has again been placed in position in the end of the shaft; in the meantime the previous reading is always available for reference. A rubber point and a hollow, or cup, centre are supplied for fitting on to the spindle and the triangular pointed end of the latter can also be used. A disc wheel for indicating peripheral speeds is also supplied, the whole

of the parts being contained in a leather-cloth covered case together with the instrument.

Both instruments described are made by the James Jaquet Company, of Basle, Switzerland, and are supplied in this country by Messrs. Markt and Company (London), Limited, 98 and 100, Clerkenwell Road, E.C.

THE LATE MR. C. T. BROXUP.

AN engineer with an extensive locomotive experience in many parts of the world, Mr. Charles Thomas Broxup, died at Cadogan House, Greenbank, Falmouth, on the 16th inst., in his 65th year. Trained under Messrs. Adams, Bromley and Worsdell, of the Eastern Counties, now the Great Eastern, Railway, he after further experience as a locomotive superintendent for the Cape Government, joined the staff of Mr. James Livesey, and later was put in charge of the locomotive department for the contractor building the Swedish and Norwegian Railway, Lulea, Sweden. This service was followed by three years' work as assistant locomotive superintendent to Mr. John W. Mavin. He went to Spain for the Orconera Iron Ore Company at Bilbao, in 1891, and spent three years there overhauling the whole of the locomotives and rolling stock. From 1895 to 1898 he was locomotive, carriage and wagon superintendent for the Lancashire, Derbyshire and East Coast Railway, and in addition to his work designing and inspecting the locomotives and rolling-stock, he assisted Mr. R. Elliott-Cooper in designing running sheds and repair workshops at Tuxford. In 1898, Mr. Broxup went to Manilla in the service of the Manilla Railway and during both the Spanish-American war and the Filipino rebellion he had some exciting experiences, being for a time held as a prisoner by the rebel chief Anguinaldo. After the insurrection he put into a state of repair or rebuilt the railway equipment, 65 per cent. of which had been either destroyed or damaged. Mr. Broxup was elected an Assoc.M.Inst.C.E. in 1896 and a full member in 1904.

CLYDE MARINE OIL ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—The consumption figure of 0·386 lb. of fuel oil per brake horse-power hour reached by a modern oil engine, cold starting type, rated at less than 100 b.h.p., quoted by me during the discussion of Professor Mellanby's paper on the above subject, read at the meeting of the Institution of Mechanical Engineers on November 30, and reported in your issue of December 7, has, judging from conversations and correspondence since, evoked considerable interest.

To prevent misapprehension it is, I think, now necessary to mention that the test was made by me in November, 1922, at the works of Messrs. Tangyes, Limited, Birmingham (Fuller details have been published by them in a separate pamphlet.)

As the name of another firm of oil engine makers has been coupled with my remarks, I should be glad if you could see your way to publish this letter.

Yours truly,
W. A. TOOKEY.

39, Victoria-street, Westminster, S.W.1,
December 13, 1923.

"POWDERED COAL FOR STEAM RAISING."

TO THE EDITOR OF ENGINEERING.

SIR,—In your leading article of your issue dated 14th inst., dealing with powdered coal for steam raising, you state that "it is somewhat unfortunate that the first installation of powdered coal in a power station in this country was what is known as the central system." As the engineer responsible for the installation in question, viz., at the Hammersmith generating station, I must take strong exception to this remark. The installation in question is a sound commercial success, has been in operation for three years and was extended in April last to two additional boilers.

In seven months from April last a saving of nearly 6,000*l.* has been made, after charging up against pulverised coal the whole of the expenditure in a central pulverising house on wages, repairs and maintenance, power and coal for drying, &c., and it is anticipated that the additional output in the following five months will double this saving. In view of these satisfactory results, what do you suggest would have been a more "fortunate" decision on my part. Five years ago, when this decision was made, viz., in 1918, I knew for a fact that in 1902, a unit system of pulverising coal had been placed on the market, was tried and evidently died a natural death. I also remembered that in 1911 a unit system was submitted to me, but failed to prove its merits over mechanical stokers, and it was not until a central system was placed before me that I was convinced that a reliable and practical scheme for using pulverised coal on a large scale had been evolved, and accordingly an order was placed with the Powdered Fuel Plant Company (who at that time did not advocate the unit system) for the complete equipment of one boiler on the "Holbeck" system.

Do you therefore suggest that it would have been wiser for me to have installed mechanical stokers rather than put in a central pulverising system, when I was satisfied that the central system was the only practical method of obtaining the advantages of burning coal in powdered form, especially the advantage from a public health point of view of "smokelessness"?

In my estimation the unit system is only a phase in the development of the use of powdered coal, and that these unit pulverisers will ultimately be replaced by the central system in all large installations.

In speaking of the central system you state that "Experience appears to prove that all this complexity of plant is unnecessary." This so-called complexity of plant only exists in the minds of those who are inexperienced and nervous about anything new. In practice the central pulverising system is delightfully simple in operation, and those who have tasted the benefits of using pulverised coal on the small scale system, will, with the growth in their consumption of powdered coal, be driven to the central system.

Again, you state with reference to the above mentioned plant, "that the anticipated troubles did not amount to anything very serious." Can you explain to what troubles you refer and who anticipated them?

Are any troubles anticipated in the case of the two installations you specifically mention later in your article? Is it not a fact that one of those has already encountered serious difficulty and is now shut down?

I am convinced that powdered fuel has a great future, there is a place for each system, but for large scale operations such as power stations, the central pulverising house, run as a separate factory for the preparation of the fuel, will prove to be the correct solution.

I am, yours faithfully,
G. G. BELL, Engineer Manager.

Electricity Works, 85, Fulham Palace-road,
Hammersmith, W.6, December 15, 1923.

[Nobody reading our article could, we think, possibly interpret it as making any reflection on Mr. Bell's judgment, when in 1918 he installed the system of pulverised coal-firing which has proved so successful at Hammersmith. Mr. Bell's letter is answered in the main by the following quotation from our article: "The fact that it has since been extended is sufficient evidence that it fulfilled its purpose in a satisfactory and economical manner, and that the anticipated troubles did not amount to anything very serious. Nevertheless, the preliminary drying of coal by heat before pulverisation, the collection and storage of the coal dust and the arrangements for feeding to the burners as desired, all of which are typical of the central system as usually carried out, are so many drawbacks, whether regarded from the point of view of the first cost of the installation, the room required to house it, or the trouble and risk of operating it." Whether the unit system or the central system will ultimately hold the field is at present a matter of judgment, but it is certainly significant that the firm who installed the very successful Hammersmith plant on the central system are now advocating and installing the unit system on account of its greater simplicity and much lower cost. With regard to the last paragraph but one of Mr. Bell's letter, we understand that the only reason for the plant being temporarily out of commission is to enable repairs to the brickwork to be carried out. These have been necessitated by the high furnace temperatures attained, and the stoppage has nothing to do with the unit system or any other system of supplying the pulverised fuel to the burners.—ED. E.]

CEMENT CONCRETE ROADS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the triennial prize essay of the International Congress (viz. the pamphlet by M. Henri Trehard, of Paris, on "Cement Concrete Roads," 1923, an admirable and exhaustive paper on this subject, now of such great importance), there occurs the following passage under the heading of "Protective Layer": "In order to diminish the wear caused by traffic and to alleviate the destructive effect of shoes and non-skid devices, the surface of the concrete is sometimes covered with a coating of tar, bitumen, or asphalt, which is renewed every year, or even at longer intervals according to the density of the traffic. This arrangement has also the advantage of covering up the expansion joints, of lessening the noise caused by traffic, of making the roads *less shiny*, and finally *of relieving the concrete from the alternations of dryness and moistness* which are so harmful to it (the italics are mine) . . . The composition of the coating to be applied should be the subject of serious study. As a matter of fact, the unfavourable results observed in this connection have all been attributed to *imperfect adherence of the bituminous compound to the concrete*, and to irregular wear in the protective coating . . . The method most frequently used consists in spreading upon the paving, by means of a spreader working with pressure, of oil containing 90 per cent. asphaltic material, . . . this oil being brought to a temperature varying from 121 deg. to 269 deg. C., &c."

I should be obliged if you could find space in your columns for the following facts: Last autumn a concrete road was opened by Sir Henry Maybury at Rhyl, in Flintshire. Part of this road (2 miles in length) was treated, at the instance of Mr. R. G. Whitley, A.M.Inst.C.E., county surveyor of Flintshire, with "Bituloid"—a colloidal emulsion of oil and bitumen, manufactured by Bituloid Roads Colloidal, Limited, and *applied cold* without requiring any special plant, merely sprinkled by an ordinary water cart. One section of the road was treated with "Bituloid" only, a second section was painted with tar on the top of the "Bituloid" to see whether the latter would form a key, and on a third there was applied a special preparation containing 30 per cent. of bitumen.

The object of this was to see whether this mixture would adhere to the concrete surface, experience having shown that so far no adhesion between bitumen and concrete was feasible. It was found that the "Bituloid" formed a most effective key, either of tar or of bitumen. Its appearance was dark brown, and thus the shining effect on the concrete surface was obviated. Where "Bituloid" was used on the road without any tar, the concrete was made absolutely waterproof. In order to keep it in this waterproof condition it should receive a coat of "Bituloid" two or three times a year, and such treatment should be given when the concrete is very dry.

The desiderata enumerated in the article quoted above, viz., (1) covering the surface of the concrete to relieve it from the alternations of dryness and wet, (2) removing the glare in bright light, and (3) acting as a key to a bituminous carpet, are, it is claimed, all satisfied by "Bituloid" at a very low cost, applied cold without the use of special plant.

I am, yours faithfully,
G. K. SCOTT-MONCRIEFF,
Major-General (Retired).

Trafalgar Buildings, Charing Cross,
December 14, 1923.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Despite the cautious attitude adopted by a certain section of consumers of steel and heavy machinery in view of the political situation, local industry generally occupies a much superior position to that of six months ago. More iron and steel plants are in operation, output has risen considerably both on home and export account, and prices, while still severely cut, are at a rather more remunerative level than was the case. The general state of order books throughout the steel trades indicates the continuance of a steady revival. Special steels are still badly hit by foreign tariffs, exports being greatly restricted, but there is growing evidence that the guaranteed quality of local manufacturers will assist the industry to survive its current experience. The United States, France, and some of the Colonies are at present in the local market for supplies. The new railway business on home account is gradually being placed. Two South Yorkshire firms are to supply 30,000 tons of steel rails to the London Midland & Scottish Railway, and in addition, a Rotherham firm has booked a contract for 100 12-ton mineral wagons. Pre-war the demand for acid steel was responsible for the major portion of South Yorkshire's output, but since the laying down of special plant basic steel manufacture has assumed a pre-eminent position, and the tendency is for it to grow. Tramway materials are an improving line, but little that is favourable can be reported with regard to agricultural engineering. Increased activity is the general rule in the lighter branches, which are anticipating better times early in the New Year. A rising demand for colliery and quarry tools and joiner's requisites is an outstanding feature.

South Yorkshire Coal Trade.—While quotations show no further advance, collieries generally occupy a strong position. Contracts absorb the bulk of the output, little remaining when these have been satisfied for open market disposal. Best steams are firmly held both on home and export account, and an active business is passing in cobbles and nuts. Smalls are firmer at recent rates. There is a strong demand for coke for shipment. House coal deliveries are badly impeded by wagon shortage. Collieries could dispose of a much larger output if the means of transport were available. Quotations: Best branch handpicked, 33*s.* to 34*s.*; Barnsley best Silkstone, 27*s.* 6*d.* to 29*s.*; Derbyshire best brights, 27*s.* to 29*s.*; Derbyshire best house coal, 23*s.* to 24*s.*; Derbyshire best large nuts, 22*s.* to 23*s.* 6*d.*; Derbyshire best small nuts, 17*s.* 6*d.* to 19*s.* 6*d.*; Yorkshire hards, 22*s.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* to 22*s.* 6*d.*; rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 5*s.* to 8*s.*

THE INTERNATIONAL AIR CONGRESS.—We understand that the full report of the proceedings of the International Air Congress, held in London in June last and dealt with on page 795 of our last volume and on pages 5 and 35 *ante*, is now nearly ready for publication. The Congress, it will be remembered, was attended by 552 delegates from twenty different countries and representing every phase of aeronautical activity, so that the report of the proceedings should constitute a valuable record of progress and a mine of useful information on civil and military aviation in all parts of the world. The report, which is bound in cloth, occupies 1,000 pages and contains not only the 63 papers read during the week of the Congress with a verbatim report of the discussion on each, but also includes a number of papers not actually read owing to lack of time. The volume has been edited by Lieut.-Col. W. Lockwood Marsh, the general secretary of the Congress, and will be obtainable from the offices of the Royal Aeronautical Society, 7, Albemarle-street, London, W.1, price 25*s.*

FRENCH FOUNDRY SCHOOL.—The under-secretary of State for Technical Education, acting in conjunction with the General Association of French Foundries, has decided to establish in Paris a Foundry school, destined to train engineers in the casting of all metals. There are to be two classes of students, in equal numbers as far as this is practicable, (*a*) students who have completed their course at the Ecole Polytechnique, the Ecole Supérieure des Mines of Paris, the Ecole des Mines of St. Etienne, the Ecole Centrale, the Ecoles des Arts et Métiers, the Institut Industriel du Nord, and other colleges; (*b*) students selected from the various works. The classes are to last one year, and are to commence early in January.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—As was to be expected a distinctly quieter feeling is noticeable, but the market is a good deal more active than is usual at this season of the year, and the general opinion expressed is that much briskness will be experienced shortly after the holidays. Cleveland pig-iron producers are fairly well placed as regards orders, but demand is almost entirely for home purposes, next to nothing being heard of export trade. No. 1 Cleveland pig iron is 106*s.*; No. 3 g.m.b., 100*s.*; No. 4 foundry, 97*s.* 6*d.*; and No. 4 forge, 96*s.* 6*d.*, all f.o.t. makers works and f.o.b. Tees.

Hematite.—East Coast hematite iron fully maintains its firmness notwithstanding increasing output. The production is being further enlarged this week by the re-lighting of two furnaces at the Normanby Ironworks of Messrs. Pease and Partners. In this branch also business is largely confined to transactions for home consumption, but one or two Continental inquiries are reported. Nos. 1, 2 and 3 are fully 102*s.* 6*d.*, which, however, is still a comparatively low figure when it is remembered that in pre-war normal times the difference in price between mixed Nos. hematite and No. 3 Cleveland pig iron was about 8*s.*

Foreign Ore.—There is little doing in foreign ore after recent rather heavy transactions, but values are inclined to stiffen. Best rubio is stated to have been sold at 25*s.* c.i.f. Tees, and market quotations are now based on that figure.

Coke.—Durham blastfurnace coke is fairly plentiful, but sellers are disinclined to accept below 37*s.* 6*d.* to 38*s.* for good medium kinds delivered to users works.

Manufactured Iron and Steel.—Firmness characterises most branches of manufactured iron and steel. Inquiries for several descriptions of material continue on quite a good scale, and the outlook is encouraging. Producers generally have quite a lot of work on hand. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles and joists, 10*l.*; heavy sections of steel rails, 9*l.* 10*s.*; and galvanised corrugated sheets, 18*l.* 15*s.* to 19*l.*

INSTITUTION OF NAVAL ARCHITECTS.—The scientific and professional institutions are of service to their members in many different ways, but in none more important than the provision of information relating to modern progress. In this respect the variety of subjects dealt with in papers and discussions is an index of the way in which the institution is meeting the demands of the varied needs of the many sides of the profession. Judged on this basis the Institution of Naval Architects must rank very high, for the papers read during the last Session, in London and Holland, and now brought together in vol. lxv of the Transactions, which was recently published, cover almost the whole field of activity. The volume will prove a very valuable addition to any library of applied science.

ON ENGINEERS.—A correspondent to the *Engineering News-Record*, New York, commenting upon the etimology and the abuse of the word "engineer," says that all kinds of machinery, including sewing machines, washing machines, &c., as well as the steam engine, are engines; why, he adds, should those who operate steam engines be called "engineers" at all. If so called, then the woman who operates a sewing or a washing machine is also an engineer, and everyone is an engineer because practically everyone operates or cares for some device designed by an "ingener," this being the orthography of the correspondent. The spread of the word is due to carelessness and inattention; "engine driver" is as bad, whereas "chauffeur," now generally used in motor-car traffic and meaning originally "stoker," is unpardonable both in French and English. But these terms are among those which cling.

PURIFICATION OF BLAST-FURNACE GAS BY THE COTTRELL SYSTEM.—In the experimental plant for the dust precipitation from blast-furnace gas by high-tension electric discharge of the Rheinische Stahlwerke of Duisburg-Meiderich, the gas is passed in a horizontal path through boxes in which wire net electrodes of alternating polarity, discharge and collector electrodes, are suspended. When the gas is subsequently to be used as fuel, it should not be cooled; but the difficulties of the electric treatment increase with rising temperatures, and the gas, which is first passed through filter bags, does not actually enter the treaters at temperatures exceeding 200 deg. C. (about 400 deg. F.). The average purification obtained of a gas containing up to 3 grammes of dust per cubic metre, down to about 0·1 gramme, (0·024 gramme at the best) would hardly be sufficient for internal-combustion engines. A further purification could, according to Dr. H. Lent, who described the plant in *Stahl und Eisen* of November 29, be secured by reducing the rate of gasflow below 1 m. per second; but the practice of shaking the earthed collector electrodes every 20 seconds in order to let the collected dust settle in the hoppers below, is perhaps responsible for the difficulties of removing the finest dust particles, since those particles released again by the shaking would not settle quickly. Pressures of 60,000 volts are used. As regards the electric energy required the process is much more economical than dust removal in the wet: but the economy depends upon other factors as well.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Employment at the Scottish steel works has shown a considerable improvement of late and a rather larger production is general. Quite a fair number of orders were booked during recent weeks at the lower prices which prevailed up till last week, and the advance of 10*s.* per ton has caused a slight check in buying, but the lull is likely to be only of a temporary nature as t is understood that n ar date requirements are not all covered yet. With the increase in the cost of production due to higher prices demanded for fuel and raw material, and a probable further increase in costs at no very distant date, it is quite expected that quotations for steel material will not only continue firm but will have an upward tendency. The outlook is more satisfactory, but it will be well on in January before any marked improvement will be felt. In the black sheet trade the conditions are unchanged and a good output is being maintained. The demand for thin sheets on export account continues very good, but the gratifying feature of late has been the better demand from the home consumer for both thick and thin-gauge sheets. The general export trade shows signs of expanding, and some quite satisfactory inquiries for different kinds of material are now in the market. No changes have been made in prices this week except in the case of boiler plates which have been advanced 10*s.* per ton since last report. The price is now 13*l.* 10*s.* per ton, delivered in the Clyde area.

Malleable Iron Trade.—The state of the malleable iron trade of the West of Scotland is gradually getting better, and a little more life is noticeable. The demand from different sources shows improvement, and employment at the works is getting more satisfactory, but export orders are not very plentiful as yet, and some revival in that side of the industry would be welcomed. Re-rolled steel bars are again in better request. Prices are firm with "Crown" bars quoted at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—A good tone continues to prevail in the Scottish pig-iron trade and business is expanding. While forward bookings have been fairly heavy of late there is nevertheless a very satisfactory amount of dealing for early delivery. Overall, however, there is much room for improvement, both in home and foreign business. Prices continue to harden, and to-day's quotations are as follow:—Hematite, 5*l.* 8*s.* 9*d.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 11*s.* 3*d.* per ton, and No. 3, 5*l.* 6*s.* 3*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week-ending last Saturday, December 15, amounted to 1,496¾ tons, the bulk of which went overseas. For the corresponding week of last year the figures were 2,293 tons foreign, and 126 tons coastwise, making a total shipment of 2,419 tons.

NEW ELECTRIC LIGHT SCHEME, SOUTH AFRICA.—The *Cape Times*, in a report forwarded to the Department of Overseas Trade, states that at a meeting of ratepayers at Beaufort West, South Africa, it was decided to raise a loan of 14,000*l.* for a new electric light scheme. According to one alternative, the present plant, which cannot cope with the demand and is being worked at a heavy loss, should be scrapped and a new electric light plant erected to supply the requirements of the town and also bulk current to the railway administration. At the present time the council is buying current from the railway administration during certain hours of the day, but under the new scheme current has been offered to the railway although no contract has as yet been signed.

COMPARATIVE COKING TESTS.—Two coking tests of new types of ovens are discussed in *Stahl und Eisen* of November 8, by Dr. Engler, coke-inspector of Waldenburg in Silesia. The first series of tests concerns a continuous double-shaft oven, put down at Glatz by Heinrich Koppers, of Essen. The two chambers are 9 m. high, 2 m. long and about 0·35 m. wide; the combustion chamber is common to the two shafts and the heating with producer gas is so conducted on the regenerative principle, that the gases are drawn downward for half an hour and then upward for the next half hour; the rate of working and other features are adjustable. The new oven gave a good coke in very satisfactory quantity and a good yield of by-products; the tar and gas yields were higher than with the old coking plants, but the yields of ammonia and of benzene did not come quite up to that standard; on the whole the results were considered distinctly favourable to the innovation. The second series of tests was also made on a Koppers oven which had been modified, on the strength of experience gained in America. The chief change made was that the width of the oven was reduced from 500 mm. and 450 mm. to 350 mm., and the advantage gained was that the coking-time, 48 hours, with Otto-Hoffmann ovens, and 36 hours with other Koppers ovens, was reduced to 18 hours and even 12 hours. It had been found in America that with the reduced time and oven-width a coke was obtained which proved more economical in blast furnaces. Analyses taken during the coking operations showed that after nine hours a change in the composition of the gases became very distinct, and that the coke was quite mature after 12 hours; 12 hours periods were then adopted for long runs of the experimental oven which had been added to a bank of 30 ovens at Waldenburg. The coke was more porous, but quite firm; the coal charge was loosely filled in and not rammed down.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—In November the coal export trade of South Wales was adversely affected by a succession of gales and the consequent delay suffered by shipping. As a result on numerous occasions a number of tips were rendered idle at the docks by the failure of expected shipping to arrive. In the circumstances it is not surprising to find that there was a reduction in the volume of cargo exports when compared with October. According to the returns of the Board of Trade the shipments from the leading ports amounted to 2,387,630 tons, a reduction of 182,227 tons, while the value of the exports at 3,045,485*l.*, recorded a decline of 268,081*l.*, and the average f.o.b. price per ton at 25*s.* 6*d.*, a fall of 3*d.* The trade of the different ports in November is shown below:—

From		Tons.	£	Per Ton. *s.*	*d.*
Cardiff...	...	1,470,914	1,850,619	25	2
Newport	...	402,901	512,927	25	6
Port Talbot	...	222,917	269,691	24	2
Swansea	...	290,918	412,248	28	4

Of the above shipments large coal at 1,536,065 tons, valued at 2,187,533*l.*, or 25*s.* 6*d.* per ton, represented 64 per cent. of the total; while small, which amounted to 775,814 tons, valued at 776,946*l.*, or 20*s.* per ton, formed 33 per cent. of the aggregate, and through at 75,771 tons, valued at 81,006*l.*, or 21*s.* 5*d.* per ton, represented 3 per cent. of the total. The average price realised for large coal was 3*s.* 3*d.* per ton less than in October, for through 9*d.* less and for small 4*d.* less. The only port to show an improvement in trade was Port Talbot, where the shipments were increased by 13,806 tons, and the value by 10,373*l.*, but the average price realised recorded a fall of 7*d.* per ton. Coal shipped from Swansea, however, yielded 1*s.* per ton more than in October. Exports from Cardiff were reduced by 101,494 tons, from Newport by 83,252 tons, and from Swansea by 11,286 tons. Steam coals, which form the bulk of the shipments, in practically all cases realised lower prices than in October. Steam smalls shipped from Cardiff, Newport and Port Talbot were reduced by 6*d.* per ton, but at Swansea were increased by 7*d.* At Cardiff they realised 19*s.*, at Newport 20*s.* 6*d.*, at Port Talbot 18*s.* 5*d.*, and at Swansea 19*s.* 2*d.* Large steam coal exported from Cardiff and Newport showed a fall of 4*d.* per ton, from Port Talbot of 7*d.* and from Swansea of 1*d.* The price at Cardiff averaged 27*s.* 8*d.*, at Newport 27*s.* 1*d.*, at Port Talbot 27*s.* 2*d.*, and at Swansea 27*s.* 3*d.* Meanwhile the congested state of the docks coupled with the nearness of the holidays is having a restrictive influence on business. Sellers generally, however, are well situated and prices in the circumstances are steady on the basis of 29*s.* 6*d.* to 30*s.* for best admiralty large and 21*s.* to 22*s.* for best steam smalls.

Iron and Steel Trades.—Exports of iron and steel goods from South Wales last week amounted to only 11,940 tons consisting of 6,680 tons of tin and terne plates, compared with 6,395 tons in the preceeding week; 3,059 tons of black plates and sheets, against 6,270 tons and 861 tons of galvanised sheets, against 1,519 tons; and 1,340 tons of other iron and steel goods, against 2,902 tons.

DANISH DOCK AND SHIPWHARF.—We read in the Danish Foreign Office Journal that a new company has been established under the name of Roedby Harbour Dock and Shipwharf, Limited (Aktieselskabet Rodbyhavn Dok og Skibsværft), with a capital of 1,000,000 kroner, fully subscribed. The new company has taken over the old Roedby Harbour Company, the director of which, M. Fischer, has been appointed technical director of the new wharf, which expects to be able to finish in the very near future a large floating dock now under construction.

TITANIUM IN GREY CAST-IRON.—A great deal of experimental research was done in the last twenty years before the war on the influence of titanium on cast-iron. The results were little in accord and no time was found during the war period for the continuation of these researches. Ascribing the want of accord chiefly to the fact that the many alloys experimented with were too rich in titanium and therefore refractory, that the titanium was added too early, *i.e.*, not immediately before casting and in the form of nitrogen compounds, and that the effects were often calculated on the titanium percentages in the charge, not on the resulting metal, E. Piwowarsky, of the Aachen Technical High School (*Stahl und Eisen*, December 6) experimented with a pure Swedish cast-iron (4·01 C. 0·13 Mn., 0·06 Si, 0·01 S, and 0·02 P), alloyed with ferrosilicon so as to contain 1 per cent., 1·75 per cent., or 2·75 per cent. of Si, and a pure ferrotitanium prepared by the thermit reaction in a Hellberger electric furnace, fusing the metals tometimes under a layer of charcoal. He found that titanium acts on cast-iron like silicon, but much more strongly, by favouring the segregation of graphite, so that 0·1 per cent. of titanium even produces the maximum segregation. This influence of titanium masks other effects. As the titanium percentage taken up is increased the graphite grain becomes finer, and the compression and bending strength of the iron are increased (the latter by 50 per cent.) More than 0·5 per cent of titanium will hardly alloy with the iron; with higher percentages titanium compounds (carbide and cyanide) appear as microscopic crystals, the carbide especially when air is excluded. The improving effect of titanium seems mainly to be due to its taking up sulphur, oxygen and nitrogen; the metal also is less liable to attack by acid.

250-TON DRAGLINE EXCAVATOR.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

(*For Description, see Page 763.*)

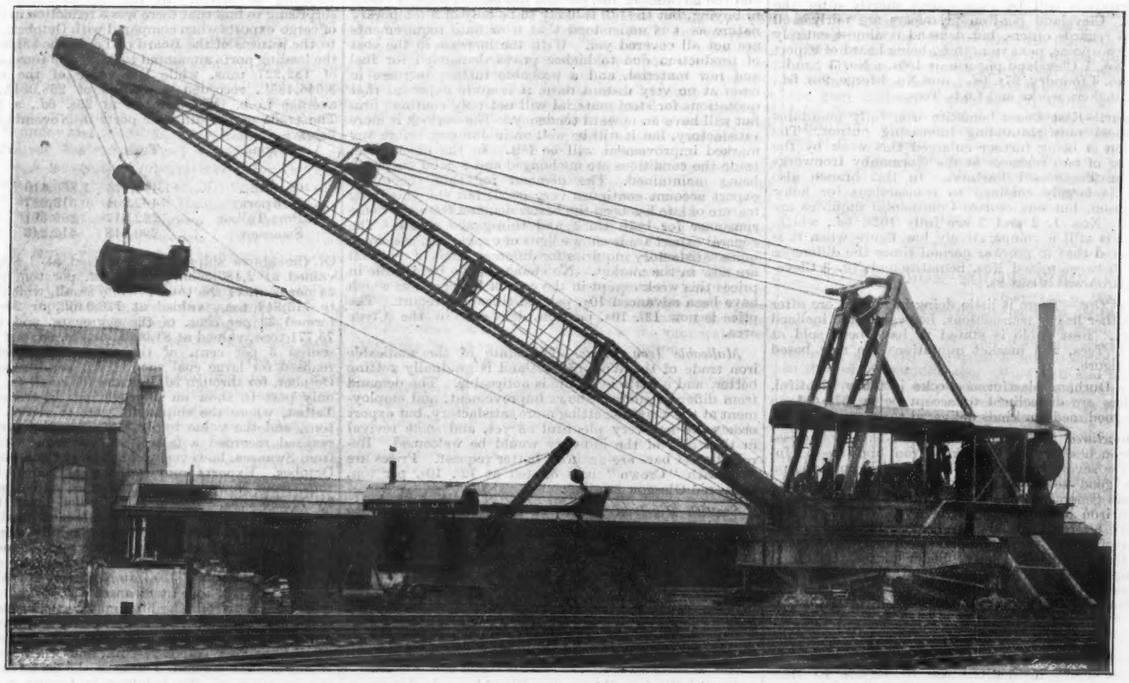


Fig. 1. General View of Excavator.

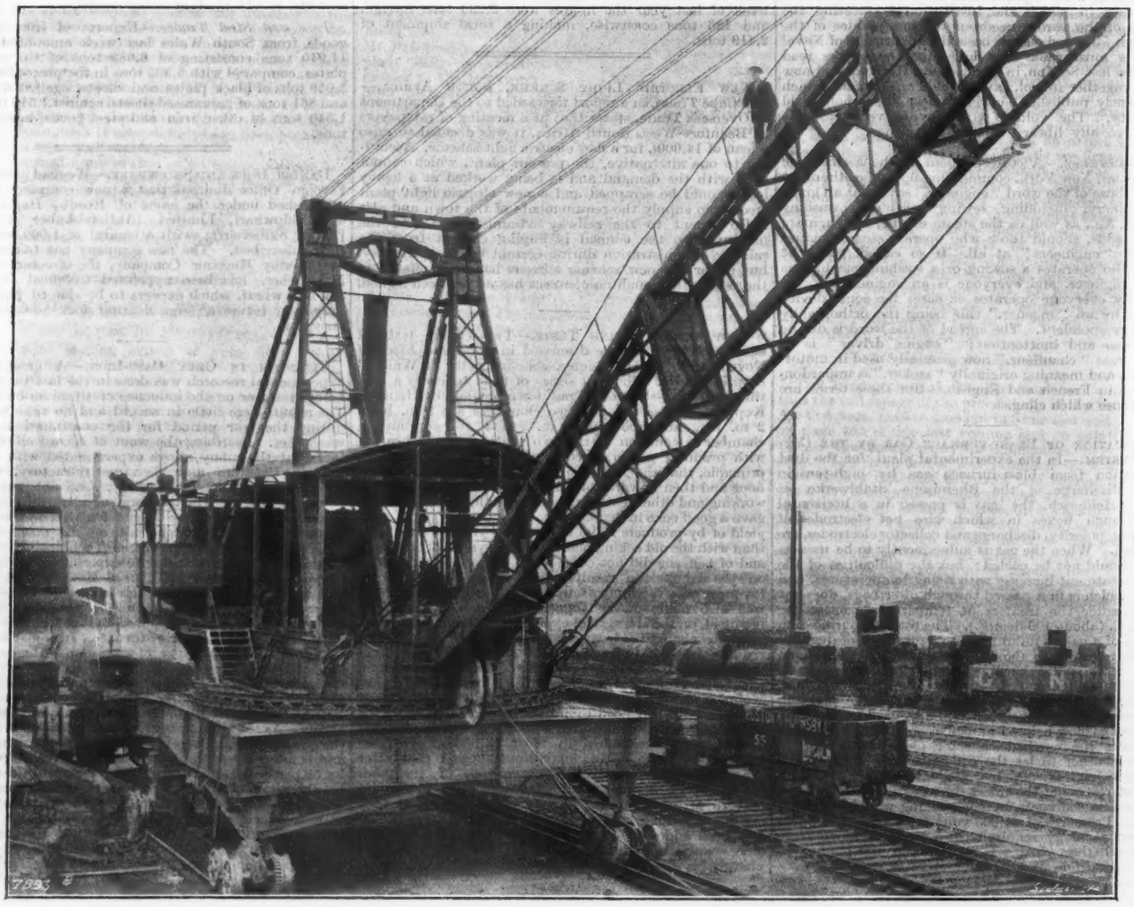


Fig. 2. Front View of Excavator.

250-TON DRAGLINE EXCAVATOR.

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(*For Description, see Page* 763.)

FIG. 3. REAR VIEW OF EXCAVATOR.

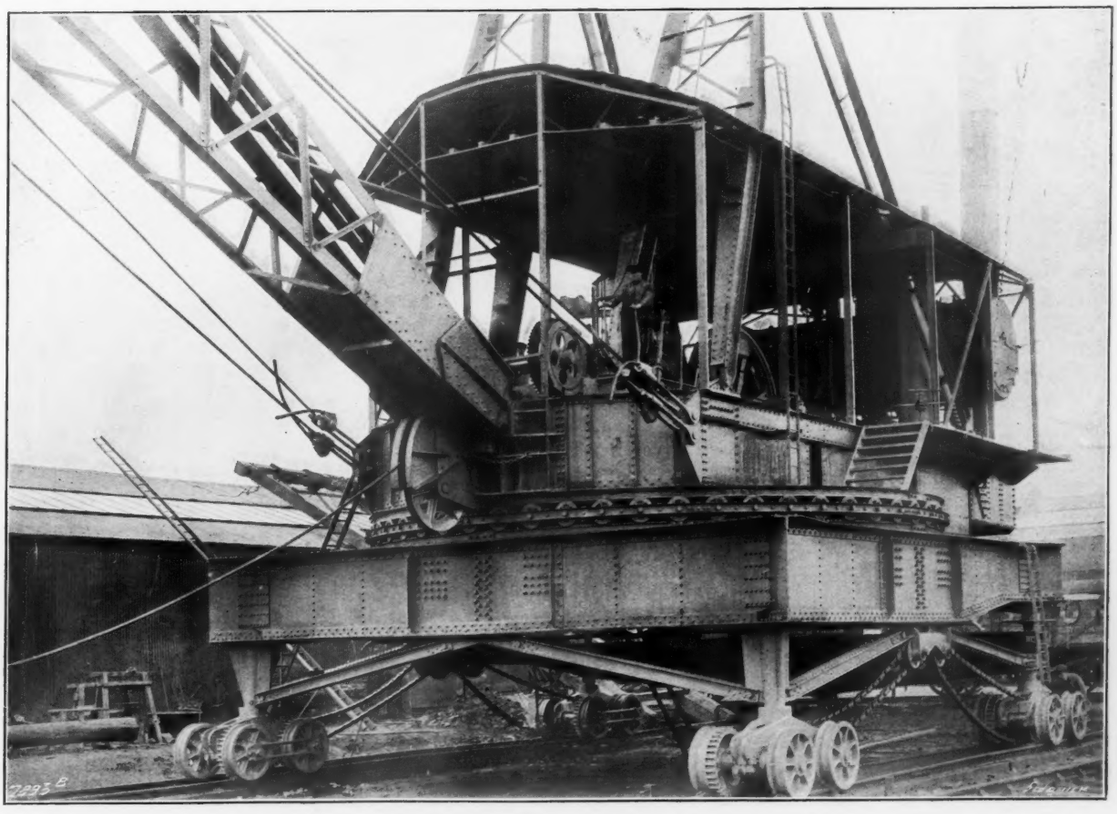

FIG. 4. BOTTOM FRAME AND REVOLVING FRAME CARRYING MACHINERY.

(*To face page* 764.)

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Fig. 5.

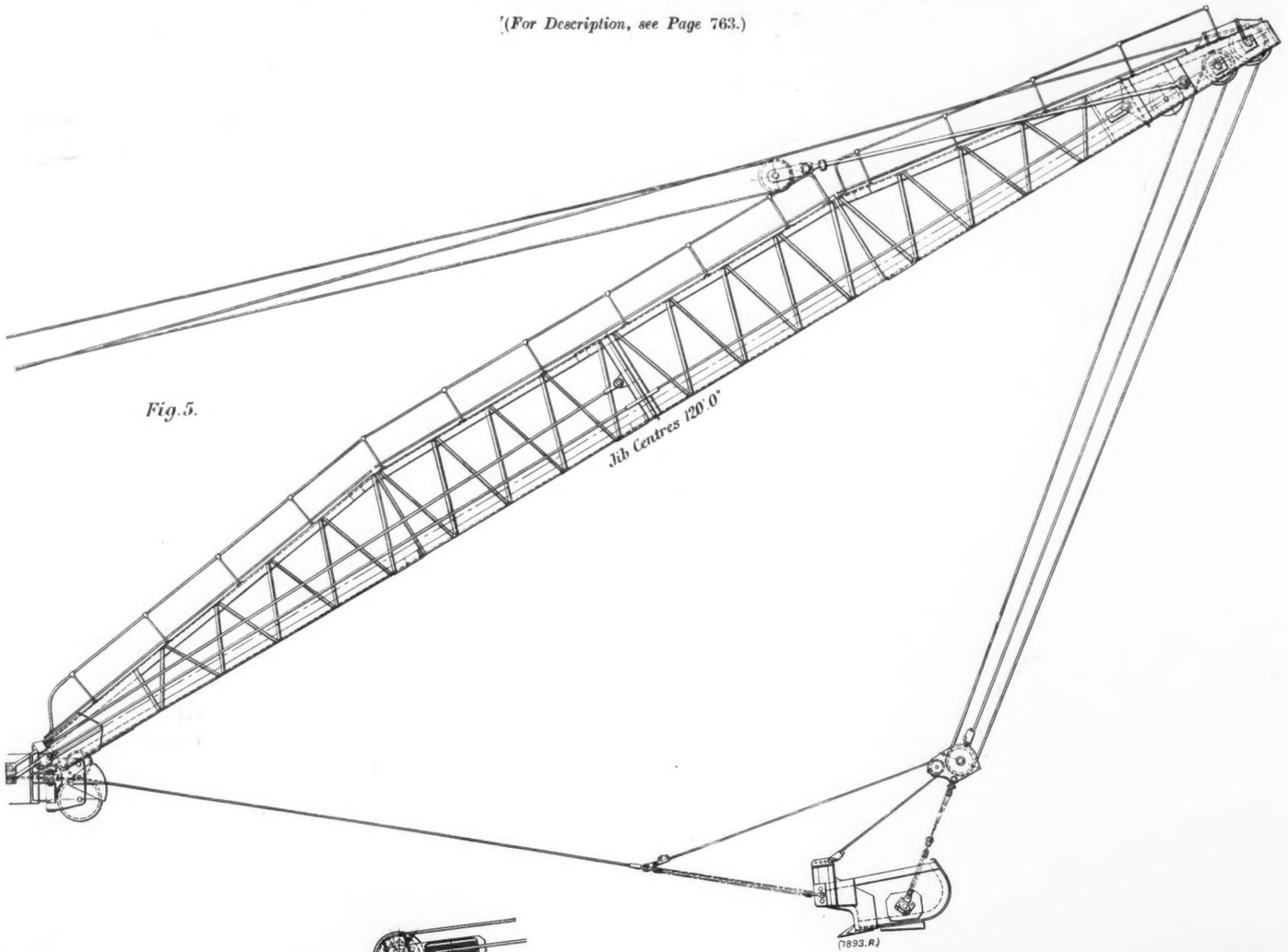
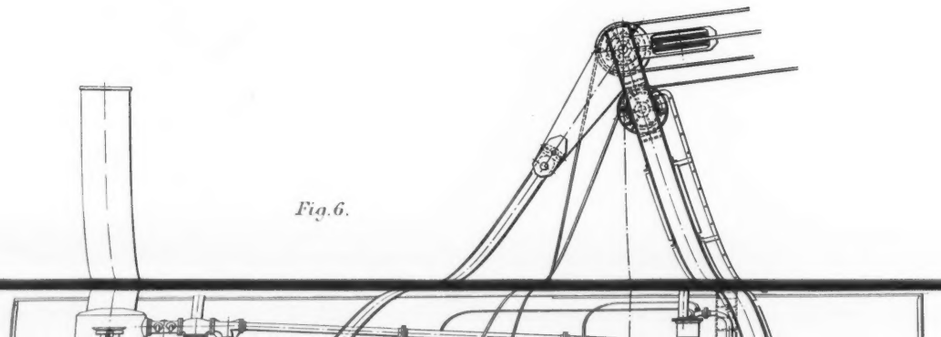


Fig. 6.



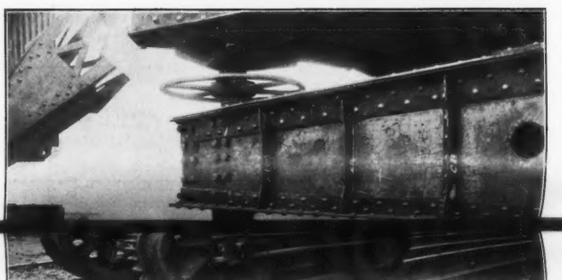


Fig. 6.

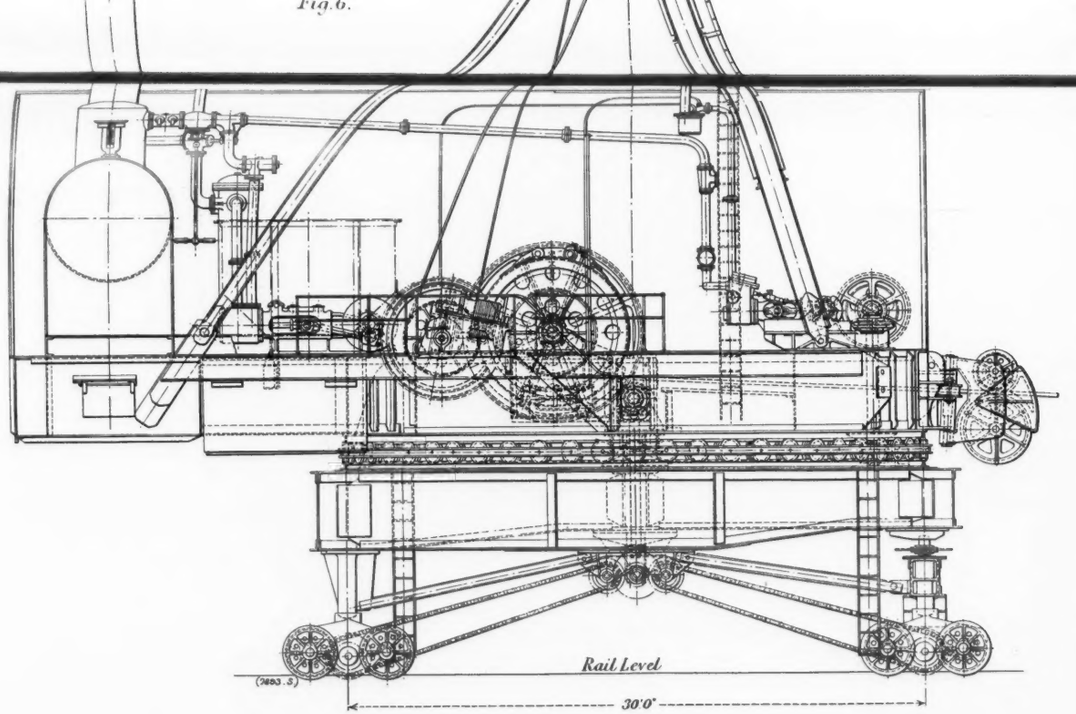


Fig. 7. Compensating Beam and One of the Bogies.

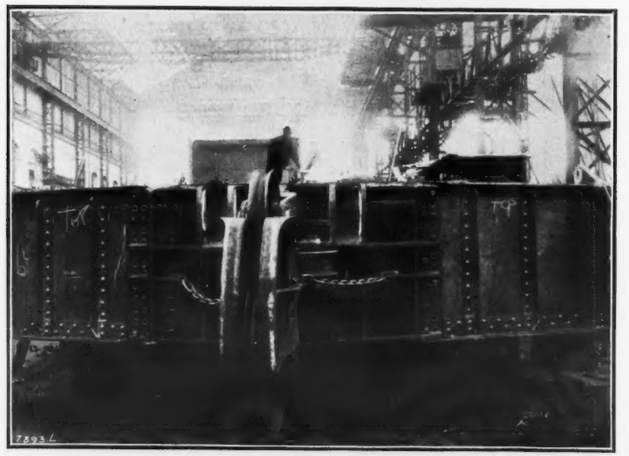


Fig. 8. Fair Lead for Digging Rope.

Fig. 9.

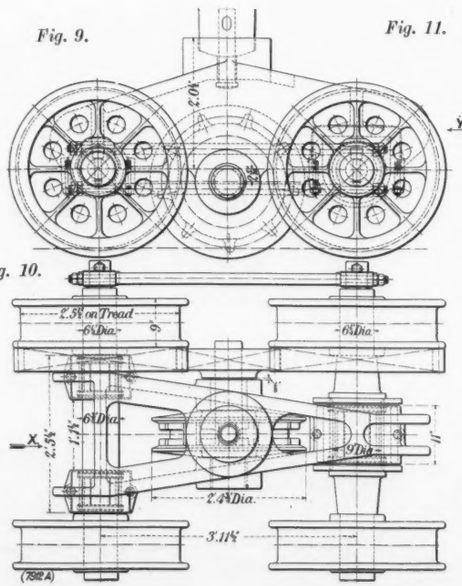
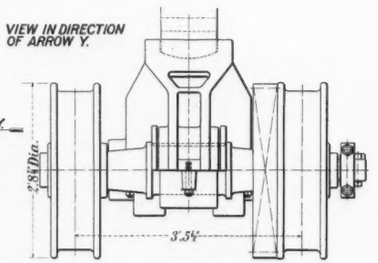


Fig. 10.

Fig. 11.



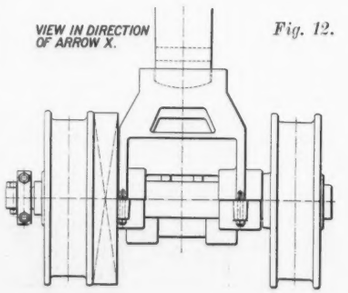


Fig. 12.

Figs. 9 to 12. Details of Bogie.

Fig. 13. View of Bucket During Digging Operations.

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(*For Description, see Page* 763.)

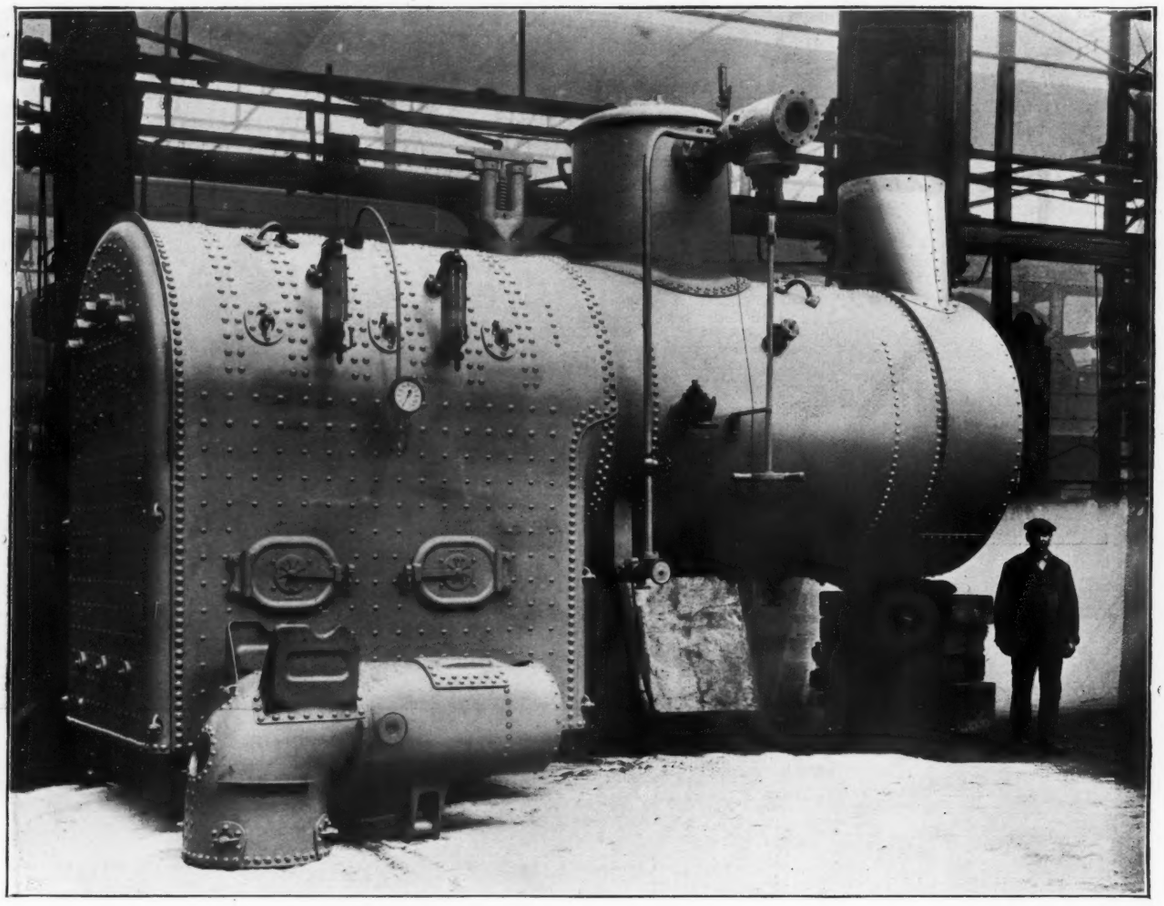

FIG. 14. SIDE-FIRED LOCOMOTIVE-TYPE BOILER.

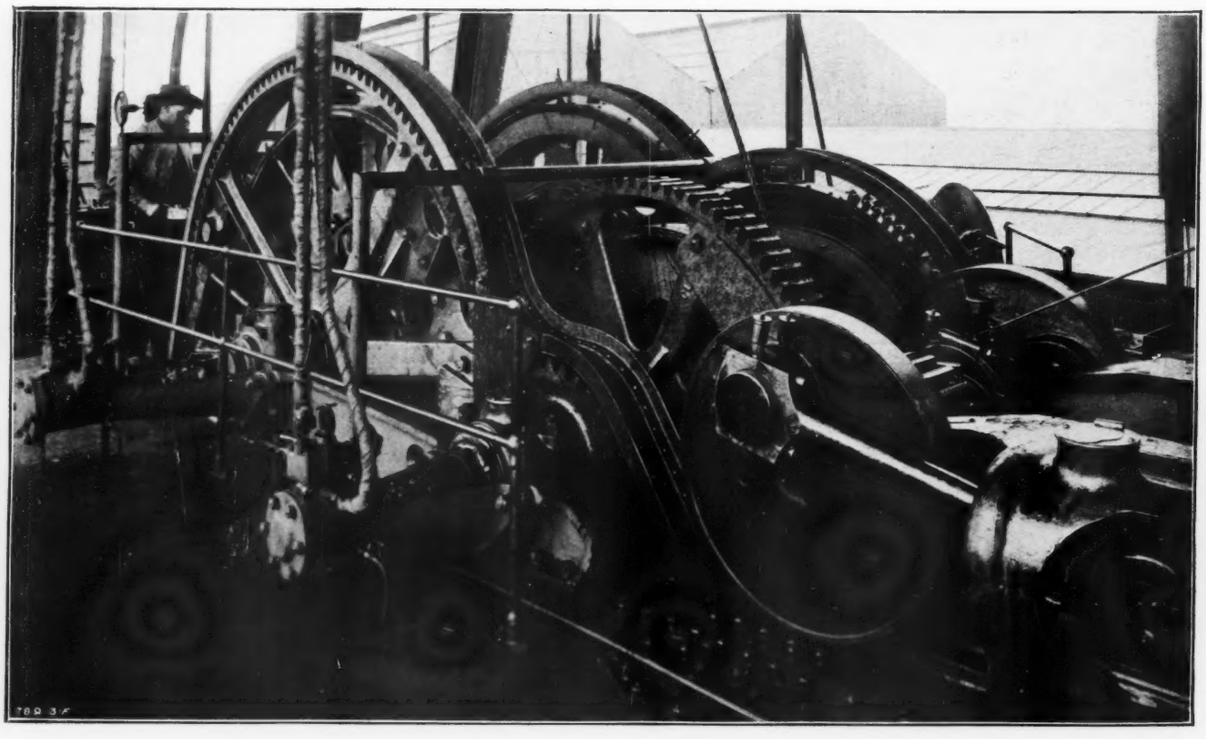

FIG. 15. GENERAL VIEW OF MACHINERY.

(*To face page* 765.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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One Two-Page Plate and Two One-Page Plates.—*250-TON DRAGLINE EXCAVATOR.*

ENGINEERING.

FRIDAY, DECEMBER 21, 1923.

THE DIRECTOR OF NAVAL CONSTRUCTION.

IT is announced that Sir Eustace Tennyson-D'Eyncourt will resign from the post of Director of Naval Construction at the end of the year. At such a time the attention of the general public is directed to the activities of a technical officer, on the efficiency of whose work depends so largely the security and well being of the Empire. It is, indeed, strange that the engineer, the naval architect and others who apply the increasing resources of knowledge to the defence of our territory and the preservation of our rights as a nation, may remain unknown outside their professional circles, although the debt we owe to them may be comparable with that we recognise as due to those who make effective use of the resources they provide. True greatness in this phase of the national defence is almost always accompanied by a modesty and lack of assumption which are found in few other fields of activity. The service rendered by such men should however never be forgotten, for without the provision of effective instruments of war the activity of those who accept the duty of directing its use would be hampered and cramped and their successful accomplishment of any feat of arms made difficult. Happy is the land which can always find the man for any arduous duty, who will not stint himself in his efforts for his nation's supremacy. In this respect we have been favoured in an exceptional way, for at no period of our naval and military history have we lacked the men of inventive ability, the designers who can develop their ideas practically, or those with the necessary qualities to control the adoption of new features in accordance with actual requirements. At the present time we are confronted with the loss of the services of one of the greatest authorities on naval construction who has led and directed the activities of the Corps of Naval Constructors and with the appointment of a suitable successor.

To gauge the value of the service rendered by Sir Eustace in his official capacity as Director of Naval Construction would entail a lengthy comparison of the design of the naval craft of all types of to-day with what was available in 1912, when he took office. In addition it would be necessary to review the various innovations that were introduced in recent years, and examine their efficiency as individual units and as parts of the general combination of machinery of warfare. Such an endeavour covering the period of the European War would indeed be a gigantic task, but although that is impossible in a short article, we must attempt to assess in some measure, even though it cannot be but quite inadequate, what has been achieved. Broad generalities then must suffice, for anything else is impossible, and on these we must base our expression of the nation's gratitude. Sir Eustace was, like so many of our greatest naval architects, trained in the Royal Naval College but obtained his experience in the activities of the great shipbuilding firms of Fairfield and Armstrongs, going from the latter in 1912 to the Admiralty to the post he is now vacating. Two years later on the outbreak of the European war there began the most arduous period in the history of the service. In the four and a-quarter years of war, the warship tonnage completed amounted to 1,602,090 and of auxiliary ships 754,111. When these figures are compared with the pre-war annual returns of less than 180,000 tons for both classes together, an estimate of the multiplication of the work of the department over which Sir Eustace had command can, in a very rough way, be estimated. The construction in those years of stress, amounting to a total of nearly two and a-half million tons involving an expenditure of about 300,000,000*l.*, exceeded that carried out in the 25 years preceding the war. Rigid airship design was added to the activities of the Corps of Naval Constructors during the war period until it was taken over by the Air Production Section of the Admiralty to which the officers in charge of the work were transferred. With such cares upon him Sir Eustace eagerly accepted the suggestion in 1915 of Mr. Winston Churchill, who was then First Lord of the Admiralty, to take up the design of landships, and he became responsible for the design and construction of the first tanks, and when the production was handed over to the Ministry of Munitions, he still remained Chief Technical Adviser on all matters relating to the subject. Apart from the remembrance of the enormous activity of the period of the war, it is possible that in the future the name of Sir Eustace Tennyson-D'Eyncourt will be remembered more in connection with the subject of underwater protection of ships than any other. The bulge protection now fitted to the ships of His Majesty's Navy was due to him, and its efficacy was amply borne out during the war by actual results, and since then during further experiments. Not only does the method provide protection from underwater attack but also from the effects of bombs dropped near to a ship from the air. The story of the work of Sir Eustace at the Admiralty is one of exceptional endeavour and remarkable achievement, and he cannot be allowed to vacate office without the expression of the gratitude felt by those who best know his work.

On some former occasions when a vacancy has occurred in this responsible position, the Admiralty in their quest of the most suitable man, with the many and varied qualities they seek, have made appointments from outside the Corps. It is true the men appointed had been trained in the Royal Naval College, but they had acquired experience in the service of the great shipbuilding firms. On this occasion, however, the Admiralty have recognised the exceptional service of one of their own men. They have appointed Mr. William John Berry, C.B., to succeed his former chief. In this action they must be congratulated, for in Mr. Berry they have a man of great experience, originative ability and administrative capacity. His career in the Admiralty has been one of most exceptional success, and the promise shown when he passed out of the Royal Naval College as the first man of his year has been amply fulfilled. Since his student days he has seen service in every grade of the Corps in both design and dockyard work. Many centres of naval construction have attained efficiency under his control and he received the thanks of the Board of Admiralty as Assistant Director of Naval Construction for his work on the design and building of H.M.SS. Renown and Repulse. The construction of one of these established a record in the production of a vessel of her size, for she was

delivered in twenty months after the department received the first intimation that a new battle cruiser was required and within nineteen months of the laying of the keel. Since June, 1917, when Sir Eric Geddes became Controller, Mr. Berry was appointed Director of Warship Production in the branch of the department supervised by Sir Thomas Bell. It is therefore a matter of great satisfaction that the man who was directly responsible for the herculean efforts in that phase of Admiralty work should have been chosen to succeed Sir Eustace Tennyson-D'Eyncourt in the important office of Director of Naval Construction.

ATMOSPHERIC CORROSION OF METALS.

In their study of building materials the Royal Institute of British Architects ten years ago took up the question of the atmospheric corrosion of metals. First cost is not necessarily the dominating financial consideration in the selection of materials; the need of protective coatings may make first advantages illusory. Protective coatings are not a radical cure against corrosion, moreover, and before we can decide what is going on underneath the sheathing, we should attempt to settle how and under what conditions the metal surface itself corrodes. The architects thus soon found themselves engaged in problems which are still occupying the Institute of Metals, the Department of Scientific and Industrial Research, and the Atmospheric Corrosion Committee of the Non-Ferrous Metals Research Association of Birmingham, working in conjunction with several firms. On behalf of these bodies Mr. W. H. J. Vernon, B.Sc., two years ago entered upon a new line of systematic research under Professor H. C. H. Carpenter, at the Royal School of Mines, and his first report was discussed in the meeting of the Faraday Society, held on the 17th inst.

So far the investigation has mainly consisted of "field tests," in which specimens, mostly 1 decimetre (4 in.) square and 3 mm. ($\frac{1}{8}$ in.) thick, of the metals are exposed to representative atmospheres in order to study in the first instance the initial tarnishing which precedes actual corrosion, and to a lesser degree of "laboratory tests" which, the discussion left no doubt, will be the chief further study. The field tests are being made in the basement of the building, where the humidity is variable, but not high; in the closed tank room at the top of the building, where saturation is sometimes reached; in a domestic kitchen in Mr. Vernon's house, heated by coal fire, where cooking and lighting is done by gas and the atmosphere is hence polluted with combustion gases and greasy vapours; and in the open air on the top of the college roof where the specimens are so suspended, sheltered or not from the rain, that the water dripping off is collected. The examination is gravimetric and by ordinary visual and by optical methods; in the latter the advancing diminution of reflectivity, characteristic of tarnishing, is studied by means of the Lummer-Brodhun arrangement of Mr. J. Guild, of the National Physical Laboratory. Mr. Guild would now, however, recommend the use of the improved flicker photometer, since it does not require a colour screen when dealing with the interference colours of the surface film, which would otherwise vitiate quantitative estimates.

Plotting the relation between the weight increment (which in due time might become loss of weight), as ordinate against the time as abscissa, Mr. Vernon finds that three types of typical curves can be distinguished: (1) A parabola whose major axis coincides with the time axis, *i.e.*, the weight increment is proportional to the square of the time, the rate of attack being retarded as the exposure is prolonged and the surface film or scale through which the atmosphere can reach the metal underneath is continuous and protective. This is the case of copper within a wide range of humidity conditions. (2) A straight line passing through the origin; the attack proceeds at a constant rate proportional to time, and the scale is permeable but neutral; this is the case of zinc in an unsaturated atmosphere. (3) A parabola whose axis coincides with the weight axis, the rate of attack being accelerated as the exposure is prolonged. In this case the scale is discontinuous and not protective; iron in humid atmosphere, reaching saturation intermittently, is an example of this kind.

In general, rough surfaces tarnish more than polished surfaces, but this difference is not marked in more humid atmospheres, except in the case of fine silver which, in the kitchen, tarnishes most when polished. There is also little difference, mostly as to tarnishing, between the hard and the soft condition of a metal; when they differ, the hard metal suffers most. The attack generally begins at or very near the edge; that thick specimens suffer relatively less than thinner ones was observed only in the case of iron. Generally tarnishing is more pronounced, even indoors, during the winter than during the summer, probably because the air is more polluted. Most of Mr. Vernon's duration tests have now proceeded for 600 days.

The chief metals so far studied are copper, zinc, zinc-copper alloys, iron, nickel and silver. The report of 62 pages gives details of the observations. Mr. Vernon ascribes the tarnishing of copper chiefly to sulphur gases (H_2S,SO_2, possibly also organic), but not to liquid or solid sulphur oxides, since filtering of the air through cotton or over granulated silver prevents the tarnishing. The presence of liquid water is not necessary, the action taking place above the dew point and increasing with higher temperature; an excess of water in fact retards the tarnishing of copper. Zinc is particularly attacked by the gases of combustion, probably by carbon dioxide. In brass the attack is, in the early stages, a function of the copper contents; subsequently a "smoky film" develops particularly over high-zinc brasses. In 60 : 40 brass the α constituent (rich in copper) is first attacked, later the β constituent (rich in zinc); solid or liquid particles (presumably sulphuric acid) are much more injurious to the β constituent than to copper, and all brasses suffer much in kitchen atmospheres.

The iron examined, a cold-rolled mild steel, differed fundamentally from the non-ferrous metals. The weight increment curve in an unsaturated atmosphere is a straight line, but the rate of increase is much greater than in the case of zinc; 32 times as great at the end of 336 days. The reflectivity is lost slowly indoors, but in the presence of rain much more rapidly. Polished nickel remains bright, but begins to fog at temperatures near the dew-point; the film can only in the initial stages be easily removed. Nickel alloys show films of fogging in humid atmospheres and a tarnishing, more like copper, in unsaturated atmospheres. As regards silver, Mr. Vernon confirms other observations as to the different behaviour of fine and of sterling silvers.

We have given a brief summary of the report of Mr. Vernon, who was highly complimented upon his painstaking work during the animated and prolonged discussion. Nobody considered his reflectivity tests as too delicate or unnecessary. Mr. Mundy, who opened the discussion as chairman of the original committee, while stating that some architects wished for practical results, was aware of the importance of a fundamental laboratory study of the problem from its earliest stages, a view which was afterwards emphasised by Professor H. C. H. Carpenter, Dr. Rosenhain and others. We wanted to understand the real nature of the films and fogs and of their differences, Professor Carpenter said that field tests were not under control, and they had had their day.

Dr. Bengough stated that he missed in the report any reference to the relation between impurity and corrosion. Mr. Vernon had not distinctly stated whether the film on zinc was continuous like that on copper; Dr. Bengough thought it must be, since a zinc coating protected iron until it was injured. Carbon dioxide was very deleterious to zinc; if the CO_2 were removed, sea water would not attack zinc. But the surface appearance might be misleading. Rolled or drawn brass might look perfectly bright in sea water, though it was so heavily corroded that the surface layer might be wiped off from the hard metal underneath.

Mr. U. R. Evans stood up for electrochemical corrosion which Mr. Vernon thought to have disproved in one case by showing that copper would tarnish in diluted hydrogen sulphide when suspended over benzene, which is not an electrolyte, all the materials being carefully dried. Absolute drying is notoriously difficult, if possible; that applied also to benzene, Mr. Evans remarked, and the presence of impurities would often make the moisture film an electric conductor. Mr. Evans also referred to Tammann's work on the importance of the rate of diffusion of gases and liquids through the surface films. Dr. Rosenhain pointed out that all metals, gold and platinum excepted, would show patchy corrosion, even after long-continued drying, unless they were cleaned with anhydrous alcohol and ether, the result depending upon the last substance with which the metal had been in contact. Anhydrous films were much less continuous than films of adsorbed moisture. The surface condition was of importance, and if mechanical methods of cleaning and polishing gave fairly the same results, chemical cleaning, *i.e.*, etching, would make a great difference; it was ruinous to stainless steels, like filing. He would not continue the field tests which had given contradictory results in different localities as to the corrosion of manganese steels, for instance, but he would make laboratory experiments also on the influence of small cavities in the specimens. Mr. C. C. Paterson suggested that this research should be commenced with vacuum tests.

Dr. Simpson, Director of the Meteorological Office, put the reasons for the unreliability of field tests clearly. We were, he stated, generally thinking too much of the constancy of our atmosphere. The air was always polluted, and changed its composition, as fogs sufficiently indicated. Local temperature differences might account for the different curves Mr. Vernon obtained in his basement, in which the temperature was steady, while in his tank room humidity had also mechanical effects connected with the size of the particles and, finally, the influence of light and ultraviolet light which produced nitric oxide, *e.g.*, should not be disregarded. Mr. Forsyth, speaking as an architect, mentioned that, while the wrought iron in old churches had kept free from rust for 700 years, he was afraid that the mild steel of ferro-concrete structures might disappoint us. Brass rings had remained bright on Purbeck marble columns within Salisbury Cathedral and had not lost weight out of doors. He was rather puzzled why bronzes were so well preserved, though the rain dripping from them coloured the stones green, without damaging them by the way. Dr. J. Fox rather questioned this statement. Lightning conductors corroded rapidly with copper chloride near the sea, and near London with carbonate or sulphate, these copper compounds being always basic. When copper dowels were cemented into stone with the aid of sulphur, the sulphide of copper formed was apt to crack the stone.

Dr. Newton Friend, Dr. Reynolds and Dr. Lessing continued the discussion partly from the chemical standpoint, referring to mercury and to gas mains. Following Dr. Friend, Mr. Vernon had spoken of initial "surrosion" instead of corrosion; the term fortunately found no support. By the time that Mr. Vernon had replied and Sir Robert Robertson, President of the Faraday Society, had closed the discussion, it was quite clear that the fundamental corrosion question still involves intricate problems, the solution of which will necessitate further research.

STATE DEVELOPMENT OF WATER POWER IN FINLAND.

Now that Finland is consolidated as an independent State, a decided impetus has been given to the development of its water resources. A good start has already been made in connection with the exploitation of the famous Imatra Falls. The whole resources of the country in the way of water power have lately been investigated and scheduled.

The greater portion of southern Finland forms a comparatively level tableland, on which are situated numerous lakes, with only slight variation in their level above the sea, which is some 70 to 80 m. The rivers emanating from this plateau may be grouped in three systems. The eastern, with a catchment area of some 67,000 square kilometres, with the large Saima lake, from where the Vuoksen flows into the Ladoga lake. The central system,

with a catchment area of 37,000 square kilometres, has its outlet into the gulf of Finland through the Kymmene river; whilst the Kumo river constitutes the outlet into the Baltic of the western system, with a catchment area of some 27,000 square kilometres. On the plateau itself there is very little water power available owing to the fairly uniform level, but on leaving the plateau the rivers referred to have a fall of between 70 and 80 m., and a very large volume of water.

The Finnish State has in the course of recent years acquired several waterfalls, and development has now been started with the most important, the Imatra Fall on the Vuoksen river. The upper portion of this river, from the Saima lake to Iääski, has an aggregate head of 64·24 m. and the volume of water at ordinary low water level is 480 cub. m. per second and 570 cub. m. at mean water level.

Preparatory work on the Imatra State power station was commenced in the year 1921. The plan for this is based upon utilising the entire head of the Imatra fall, the Linnankoski and the smaller falls in the Vuoksen. Prior to the regulation of the Saima lake the power station, with a volume of water of 600 cub. m. per second, is calculated to have a capacity of 153,600 turbine h.p. and after the regulation a capacity of 250,000 turbine h.p., according to future load conditions. The first instalment will be of a somewhat smaller capacity, in so much as the head will be about 1 m. less until the final storage above Linnankoski has been completed. The inlet canal is in the first instance to have a section of about 280 square m. and the outlet canal of 140 square m. The power station itself is planned, as regards the construction of buildings, &c., for a capacity of 94,000 turbine h.p.; machinery in the first instance is to be installed for 70,500 h.p., which corresponds with a volume of water of about 300 cub. m. per second. Those portions of the buildings, &c., which cannot well be extended subsequently will be constructed for the final capacity, and other portions so that they can be promptly extended whenever required.

During the first period the Imatra power station will have a capacity of 47,000 high voltage kilowatt, which with the calculated cost of 161,000,000 Finnish marks (119,500,000 Finnish marks for buildings and necessary land and 41,500,000 Finnish marks for plant) will work out at 3,426 marks, Finnish, per kilowatt, and the annual cost per high voltage kilowatt at 462 marks Finnish. The Imatra power station is expected to be ready in 1927.

Although the Imatra Falls are the most important and those best suited for immediate development, Finland possesses a number of other large waterfalls suitable for exploitation, aggregating a capacity for the part of the country south of the system of the Ule river, of about 1,200,000 turbine h.p. without any regulation. This figure includes a number of smaller falls, of which several are already exploited, but the falls in the Vuoksen, the Kymmene, the Kumo and the Ule rivers, without any regulation, have an aggregate capacity of about 875,000 turbine h.p., at mean water level, of which at present about 90 per cent. are still unexploited. The capacity in turbine horse-power of Finland's entire water power is calculated at 1,059,400 h.p. at mean low water, for nine months of the year at 1,314,000 h.p., at mean water level at 2,540,000 h.p., and at mean high water level at 8,582,000 h.p.

NOTES.

MARINE REDUCTION GEARS.

IT has long been recognised that the pinions of marine reduction gears must twist under their load, and hence, if a uniform bearing of the teeth is secured at no load, there must, at full load, be an unequal distribution of tooth pressures. Probably in practice the teeth wear so that a fairly uniform bearing is obtained in normal running conditions, but the torsion of the pinion is undoubtedly detrimental to the good behaviour of the gear. Various proposals have been made for mitigating the evil, and it was, of course, to this end that Mr. McAlpine devised his floating frame. Mr. Ljungström again has in some cases adopted the plan of using very long teeth, the roots extending far below the pitch line, although the effective working part of the dedendum is of merely the usual proportions. The flexibility thus provided will, of course, reduce concentrations of the stress, and the nominal bending stresses on pinion teeth are commonly so low that the exceptional length of the teeth involves no dangers. A modification of this idea was suggested by Mr. Wm. Sellars in a paper read before the Institution of Marine Engineers on Tuesday last, the 18th inst. Instead of making the teeth uniformly flexible, as on Mr. Ljungström's plan, Mr. Sellars proposes to grade the flexibility, making it a maximum at points where there is a tendency for the load to concentrate, and less elsewhere. This grading of the flexibility he proposes to secure by milling out the metal between the roots of the teeth to varying depths. In this way it is hoped to provide, at least theoretically, nearly perfect compensation for the pinion's lack of torsional rigidity.

ENGINEERING ADVANCE.

The engineer in his professional work deals with concrete facts and laws, and the results he obtains logically follow the premises. One effect of this is that if he makes mistakes they come to light. As Sir Henry Fowler said, when proposing the toast of "The Houses of Parliament" at the annual dinner of the Institution of Mechanical Engineers on the 13th inst., you cannot lie to the elements. In this respect the effect of the activities of the engineer differs radically from that of some other professions, but this valuable quality which inheres in his work introduces its own difficulties. Modern engineering has become so complex and its interests so widespread that it is difficult for the members of one branch of the profession to follow all the ramifications of their own work in other spheres. This difficulty may partly be met by closer co-operation between the practitioners of the various branches, and it was most satisfactory to hear the President, Sir John Dewrance, refer to this matter in responding to the toast of "The Institution" at the dinner to which we have referred. As Sir John pointed out, it is particularly in connection with research that this co-operation has been manifested. This is very material, as there are many investigations the results of which are of value and interest to very diverse branches of engineering. The Institution of Mechanical Engineers has been a pioneer in work of this kind and has at no time shown any signs of slackening. Sir John was indeed able to refer to a further step in work of this kind in the form of the new research fund, to be called the George Stephenson Fund, which owes its initiation to Professor Coker. An aspect of the same matter of the increasing complexity of engineering and the effect of research on practice was referred to by Mr. W. H. Patchell when proposing the toast of "The Visitors." Mr. Patchell pointed out that, for instance, in connection with aircraft, there were many things which were now matters of everyday manufacture which but recently were the subject of abstruse research.

THE MODERN ROTARY DRILLING SYSTEM.

The paper on "The Modern Rotary Drilling System," which Mr. L. R. McCollum read before the Institution of Petroleum Technologists on December 11th, and an abstract of which we publish on page 785 of this issue, was illustrated by a large number of slides exemplifying details of the machinery and tools used as well as the rapid developments of oilfields which have become possible under this system in California and during the last few years also in other countries. The discussion turned mainly on the difficulties, about which, Mr. H. Barringer, President of the Institution, remarked, Mr. McCollum had said little. Mr. Campbell M. Hunter mentioned that he had introduced the rotary rig in Argentina, where the formations were very puzzling. They had met with 92 entirely different samples in drilling through 338 ft. The cable tools had proved hopeless, but with the rotary system drillers did not know exactly in what formation they were actually at any moment. To overcome this difficulty they had stopped operations every half metre, and they had also gone back to the original Fauck system, by forcing the mud down outside the rod and bringing it up through the core of the barrel. Speaking as a geologist, Mr. Dewhurst admitted that the introduction of the core barrel, novel forms of which had been described by Mr. McCollum, had partly met the objections of the geologist that the rotary system did not give reliable geological information. The cores might look better, however, than they proved afterwards, since all the oil in a sand was not really recoverable. Mr. Dewhurst supported Mr. McCollum's statement that the clay mud would quickly adhere to the sides of a channel cut through a column of sand, and that the mud film would remain permanent. At the same time he referred to cases where the petroleum had found its way from a producing well to other wells, 300 ft. and more away. Mr. McCollum replied that this might happen in practically-exhausted fields where fissures and avenues were left. Oil, gas or water would generally be found immediately underneath a hard formation. The mud would bring that material up at once and would not push aside the ground drilled through.

COLLOIDS IN INDUSTRY.

The British Association has now completed the compilation of available information on the advances that have been made in capillary and colloid chemistry, with special reference to industrial processes, and the fifth and final report of its committee on the subject has just been published by the Research Department, which with the concurrence of the Association has added a useful name and subject index to the entire series. The work of compilation, which was begun in 1917, has evidently proved larger than was at first expected, and in addition to numerous specialists who have collaborated the membership of the committee has grown steadily from 4 to 24, and the reports of their labours occupy nearly 1,000 pages of small type. They are composed of a number of sectional monographs, each dealing either with scientific results or with industrial applications, and though necessarily there has been some overlapping, the subdivision has made individual subjects more conveniently accessible, especially with the help of the index. The extent to which engineering industry is interested in the matter is greater than is sometimes realised. The colloidal condition may arise either from the dispersion of particles of macroscopic or even microscopic sizes into smaller particles of microscopic or ultra-microscopic size, down to a minuteness approaching 5 $\mu\mu$, or from the condensation of various-sized small particles, and the circumstances that determine these changes happen far more often than they are understood or even recognised. Apart from lubrication, in the phenomena of which capillary and allied forces seem to be involved, the most important application of colloidal and similar properties in the engineering industries seems up to now to be the dressing or separation of metalliferous ores by processes of froth flotation, which at the present time are estimated to be treating some 60,000,000 tons of low grade ore and slimes per year, and even now have not been applied economically to coal washing. The setting of cement, the formation and precipitation of smoke, the electro-deposition of metals, and the preparation of liquids for preventing glass from being dimmed by water, are only a few of many examples of other applications of the same or similar phenomena that have already been made. It must be agreed, however, that up to now the information on the subject is itself in what may fairly be called a colloidal form. It includes a vast number of more or less minute observations, but they are suspended in relatively turbid doctrines, from which the observations have hitherto declined to separate out into coherent conclusions. The present compilations doubtless furnish a step in the direction of clarifying the situation, and it is to be hoped that further progress will follow without undue delay.

THE EXTRACTION OF VEGETABLE OILS.

Owing to the great variety of oil-yielding seeds and the fluctuations in their supply and prices and in the demand for cattle-food cakes, few mills in this country are in a position to concentrate on one or two particular seeds. In many cases cotton and rape seeds, soya beans, ground nuts, copra and palm kernels, &c., may have to be dealt with at different periods, and the plant cannot be equally

efficient for the various raw materials. These materials are, besides, no more all mature than the fruit offered in our markets, and still less free from dirt. Dealing with these difficulties in a paper on "The Extraction of Oil from Seeds, Nuts and Kernels," read before the Chemical Engineering Group of the Society of Chemical Industry at Liverpool, on December 12, Mr. J. T. Brewis pointed out that while small seeds could generally be cleaned in revolving cylinders or on trays; ground nuts, to which the loamy soil was sticking, and palm kernels, were better treated in tumblers (inclined cylinders), not provided with perforations, in order to loosen the dirt prior to removing it by screening. The woolly cotton seeds were especially troublesome in dust cleaning, when a long lint covered the short fibre on the hulls; that lint had to be opened out by means of saw gins or by defibrating machinery of the household grater type. As regards pressing, American practice, with its highly-specialised cotton machinery, differed from English practice. In America it was considered that the pressing of the decorticated kernels (the meats, after separation from the hulls) gave a higher yield of a better and more easily-refined oil and more highly-concentrated cattle cakes than the crushing of the undecorticated seed which was generally practised over here, because the plant was more generally available for various materials, and the farmers did not at all object to the hulls in the cake. American mills separated 98 per cent. and more of meats from the hulls, but farmers liked cakes rich in linseed and cotton oil, &c. (up to 8 per cent.), so that intensive pressing became less important. In the open Anglo-press the pressure on the cake was about 1¼ tons per sq. in., against 2·8 tons in the closed cage press. In cage palm-kernel presses pressures of 4 tons per sq. in. were used to obtain firm cakes, but that was expensive and would be of little use for copra and ground nuts, and for high oil yields from a wide range of hot-pressed seeds the Anglo system had advantages, certainly with small seeds. It was very difficult in heavy cage presses to regulate the ram speed, especially during the early stages of pressing. Extraction by solvents, Mr. Brewis stated, had much developed since the war, there being several plants dealing with 1,500 tons of seeds per week. In general suitability petroleum spirit (benzene) ranked highest as solvent, but it was inflammable and involved heavy insurance charges on plant and buildings. It was therefore being replaced now by non-inflammable trichlorethylene, which had greater penetration and produced more oil per plant unit at smaller solvent losses and lower steam consumption for evaporation, but was certainly more expensive. The stationary extractor pot of a capacity of 2½ tons of seed fitted with vertical drivers was still in more general use than the many rotary pumps proposed.

"CONCRETE AND ORDERED KNOWLEDGE."

By W. Marriott, M.Inst.C.E.

The President of the Engineering Section of the British Association, Sir Henry Fowler, K.B.E., used a term in his address which one would like to see more often adopted. It is "ordered knowledge." He further went on to state that the terms "scientific" and "practical" should be synonymous. Unfortunately they are not, and therefore they should be welded together into the new term of "ordered knowledge." There are many things that have been done in the laboratory with the greatest success that cannot be repeated practically on a large scale. The writer has, unfortunately, known that fact in the case of friends who have invested money on the strength of laboratory experiments which were never able to be reproduced, and we have an object lesson in the County of Norfolk of millions of tons of oil shale, containing up to 70 gallons per ton, lying idle and dormant because, we understand, of the difficulty of eliminating sulphur, although it had been done, and could be done, in the laboratory.

Concrete in this country has not been looked upon with "ordered knowledge." The literature on the subject by Faber, Andrews, and others, is in many people's opinion, equal to anything that has been written, but much remains to be done from a practical point of view if we are to come to that state of ordered knowledge which obtains in such countries as France, Denmark, Switzerland, &c. In many ways the text books on the subject are purely theoretical and not practical.

For instance, it is quite true that concrete mixed with a very small water content is stronger than concrete mixed with larger water content. The writer will not here go into the text book definitions, but they do not say that concrete with a small water content is usually porous, and therefore not to be depended upon for reinforced work. Also that if one wants a concrete non-porous which will go well round the reinforcement and be waterproof without needing any compounds, you require from 3 per cent. to 5 per cent. or even more water, although the concrete may not be quite as strong. The danger of damp getting at the reinforcement, causing rust, electrolysis, &c., is far more to be feared than a somewhat weaker concrete. To give a case in point, it may be mentioned that an engineer friend was concreting up a large girder, using the smallest quantity of water, *i.e.*, the minimum text book allowance, and when the shuttering was taken down he was dissatisfied with the results of the work, although one might have called it sound and good. Later on he came to see the writer who explained his views in connection with some of the work for which he was responsible. Consequently the engineer resolved that for any further girders the concrete should be wetter, in fact, concrete for reinforced work should be "cast." The result was very different and highly satisfactory. This may be said to be a case of "ordered knowledge."

The writer had the other day to break up some concrete on some large sea protection work he had been carrying out, and as it had been made 9 to 1, he thought that there would not be much difficulty. The concrete proved so hard that he had to change his plans and thereby saved a very large sum of money. He therefore made an investigation into the reason why concrete of such a weak mixture should be of such excellent quality. It could not be entirely due to the mixing because some of it was hand-mixed and some of it machine-mixed. The conclusion come to was that the concrete was ideal. The cement used (mostly well-known brands) was excellent, but above all, the mixing had been excellently done and the aggregate absolutely clean. The same remarks applied to about 2,000 2-ton blocks, many of which had been lying in the sea for some two years and had been recovered when the permanent works were completed.

The density of the concrete and its hardness, though only 9 to 1, excited unusual interest, and may be said to be the result of good mixing and splendid cement with excellent aggregate. Even granite may need washing. One of our oldest firms, J. Ellis and Sons, always wash after crushing, and the mud obtained is surprising.

Now with regard to mixing. The old-fashioned hand-mixing properly done, shovel to meet shovel, and turned three times over, was expensive, and took time, but did its work well. With many of the mixers on the market to-day it is apparently assumed that rolling the materials round mixes them, but in most cases the first thing necessary to be done is to re-arrange the internal parts of the mixers to one's own liking. This the writer has himself had to do.

If we are to save cement and make a strong concrete, more attention must be given to mixing. If this is done, it will even be possible to use sand containing a small amount of loam or clay. This, though it may delay the setting to begin with, has been proved by tests to even slightly increase the strength after twenty-eight days, provided always that the stone is not coated with loam, which is fatal.

It would be a great advantage in many foreign countries where clean sharp sand is not available, to be able to use the silt of the country. But it must be proved that each particle can be efficiently coated with cement.

What is the ideal method? It appears that the aggregate should be to commence with quite dry and first of all mixed in a dry clean mixer, no water being added. This would avoid what we see continually done, viz., aggregate tumbled into a wet mixer, the cement put on the top and clinging to the sides of the mixer, forming nodules on contact with damp aggregate and consequently making concrete that is not thoroughly homogeneous. If from the dry mixer the already mixed aggregate was passed through a wet mixer, it would no doubt cost a little more, but this would be covered by the increased strength of concrete and less cement required. Mixers are also often left in a filthy state. The writer insists on cleanliness and the mixer being cleaned out each day after use, otherwise lumps of half-set material find their way into the mix.

The ideal would seem to be for the aggregate to be slightly moistened after dry mixing, and then passed in a fine stream through a chamber where the finest ground cement was held in air suspension, thus coating every minute particle, the required water being finally added. This may perhaps be a counsel of perfection, but after all it is something to aim at, and when we attain it, and not till then, shall we be able to use less cement, cheapen our mix and improve our work. It is to be hoped that with ordered knowledge we shall one day attain to this consummation.

Fine grinding would here be a *sine qua non*, and the writer would here refer to Mr. Butler's paper entitled "The British Standard Specification for Portland Cement," read before the Institution of Structural Engineers. He there points out that the residue allowed on a 180 sieve is 14 per cent., while for export purposes it is ground as low as 5 per cent. to meet foreign competition—an average of 25 English samples gave 7·4 per cent. residue.

We seem to be behind other nations at present in this ordered knowledge. We need trained workmen and supervisors. We need engineers to specialise and become enthusiasts. Evidently the great captains of industry see a concrete age looming, or we should not have the interest shown in cement production that we now read about. With such control as can be given by those who are now taking an interest, the industry ought to go ahead. The writer sees men from all over the Empire, and is often astonished at how little is known of the possibilities of concrete. Given a reduction either in price or in the cement content by more ordered knowledge, as indicated, these possibilities are infinite. The writer will never forget a remark made by the late Lord Allerton (to whose energy and foresight the Great Northern Railway owes so much), "In a few years time you will be doing things in concrete you do not now dream of." He has proved to have been a man with vision.

Much more might be said on such a subject, *e.g.*, the revision of the British Standard Specification. This has been effectively dealt with in Mr. Butler's paper, and only needs support by other such experts to bring it about. The state of affairs is much more hopeful than a few years ago. Anti-concrete engineers are happily fewer in number. Unfortunately, however, companies interested in the sale of cement have persuaded the inexperienced that the use of concrete is the simplest of processes. Such propaganda has somewhat defeated its own object as concrete made by the inexperienced is so often unsatisfactory that discredit is brought to concrete in general. Could scientific and practical knowledge be welded into a universal "ordered knowledge" concrete would take the place it deserves in the engineering world.

LITERATURE.

Brassey's Naval and Shipping Annual. Edited by Sir Alex. Richardson and Archibald Hurd. 1924. London: William Clowes and Sons, Limited. [Price 25*s.*].

Outstanding interests in naval affairs are still determined by the Washington Treaties and in mercantile shipping by the continuing freight depression throughout the world, and the questions raised by these vital matters necessarily colour very many of the contributions which go to make up the latest issue of "Brassey's Annual," with which it reaches its thirty-fifth year of publication. The value of a yearly review of this kind which sums up the questions of the year in naval and shipping matters is very great, and it is hardly too much to say that no one who desires to keep properly abreast

of the questions affecting these services can afford to neglect the authoritative opinions and dissertations which appear each autumn in its columns.

One effect of the Washington Treaties, which was by no means unforeseen by many people, has been that naval competition hampered in one direction has shown signs of becoming accelerated in others. This effect may be traced in many of the naval contributions to the Annual and the chapters on "Aircraft Carriers," by Mr. H. G. Williams and "The Trend of Research and Design in Aircraft Engineering," by Brigadier-General Bagnall-Wild are directly concerned with a branch of activity which under any circumstances was bound to receive an increasing amount of attention, but which limitation in other directions has forced into the position of becoming the most important arm in which free competition is still possible. This condition has led to the matter attaining an even greater prominence than would have been likely if the Washington Treaties had never been signed. As Mr. John Leyland points out in the chapter on "Foreign Navies," all the chief maritime Powers are strengthening the air arms of their fleets. It is of great interest to note from this chapter that "only in Great Britain has the fleet been deprived of its freedom to provide for its own needs in this direction."

The design of aircraft carriers is probably the most important technical naval problem of the moment, and Mr. William's chapter will be read with great interest in that it not only reviews existing practice, but from a consideration of the conditions of the problem leads up to a suggested design for a 26,200-ton ship of this class. This is about the largest possible vessel which can normally be built under existing conditions as the Washington Convention limits aircraft carriers to a maximum of 27,000 tons, although each contracting power is at liberty to build two aircraft carriers not exceeding 33,000 tons standard displacement. Mr. Williams' 26,200-ton boat would have a speed of 34½ knots, and by increasing the displacement to 30,500 tons he obtains a speed of 36·3 knots. This may be compared with the 31 knots of the 19,100-ton Furious and the 24 knots of the 22,790-ton Eagle. It is of much interest to note that a superstructure carrying the funnels, control station, anti-aircraft guns, &c., has been adopted in the proposed ship, and that the flush deck arrangement of the Argus has not been followed. This superstructure is employed in the two latest British Navy aircraft carriers, the Eagle and Hermes, of which particulars and illustrations were given in our columns on November 2 last.

In his review of the activities connected with the British Navy during the year, Commander C. N. Robinson deals with the proposal to construct a naval base at Singapore, and naturally has little difficulty in disposing of much of the very ill-informed criticism which has been directed against the project. If the British Empire is to become and remain the entity of which many dream, its arrangements for proper defence must be world-wide. Of the two new capital ships, Com. Robinson states that they will carry nine 16-in. guns in triple gun turrets, and will be 680 ft. long and 106 ft. beam. The anti-torpedo bulge will be fitted inside instead of outside the hulls. The chapter was written too early to contain any mention of the new light-cruiser programme, but that that programme was necessary is evidenced by Com. Robinson's statement that "in every country but Great Britain steps have been taken to provide new light cruisers of post-war design."

The large amount of information in Mr. Leyland's long chapter on "Foreign Navies" we have not space to comment on, and must pass to the important and authoritative chapter from an unnamed writer on "The Jutland Controversy." This chapter is likely to command much attention, as the author's judicial review of the circumstances of the action and of the evidence available renders it clear that the matter is being dealt with by one who speaks with great authority. It is not possible to follow the argument here. Some 19 pages of Brassey's Annual are necessary to present it without any padding, but it may be said that a complete justification for Admiral Jellicoe's actions throughout the engagement is established. A further chapter which deals with an aspect of the naval side of the war, is that on "The Development of Blockade Policy," by Mr. Archibald Colbeck, which shows that our blockade of Germany was in many aspects unprecedented, and that so far from our power in that direction having been weakened in the few years before the war, as was stated by many people, our powers at the outbreak of the war were enormously greater than they were at the time of the war with France in 1700.

The Naval Section contains in addition chapters on "The Progress of Directional Wireless," by Dr. W. H. Eccles, and "Electric Propulsion of Ships and Electrical Ship Auxiliaries," by Mr. L. Miller. Dr. Eccles writes in a very clear way about a difficult subject, and his chapter will give even the general reader a good working idea of his basis of directional wireless. Mr. Miller, by devoting a considerable amount of his space to electrically-driven auxiliaries pays attention to an important part of his subject on which not a great deal has been written. Further chapters in the naval section include a history of the Institution of Naval Architects by Mr. R. W. Dana, the well-known secretary and a graceful appreciation of the late Mr. Julian Corbett, the naval historian, by the two editors.

The Merchant Shipping Section of the Annual opens with an article by Sir Westcott Abell entitled "The World's Mercantile Marine." This contribution is not likely to disappoint those who are familiar with the contributions which Sir Westcott has made to Brassey during the last few years. His acute analysis of present-day conditions is this year followed up by a review of the various international understandings in maritime affairs which are gradually being worked up to. The same subject in some of its branches is followed up in the chapter on "Shipping and International Law," by Sir Leslie Scott. The chief technical article in this section is that by Mr. James Richardson on "Marine Engineering of To-day." Although the shipbuilding slump has been, and is, a great handicap on the working out and trial of new methods it forms in another aspect an incentive towards such new methods. As Mr. Richardson points out "the average age of much of the shipping on the high seas to-day is too great for the best economy of transport and minimum maintenance costs, and many ships must be replaced at an early date. The degree of insistency of the call for replacement can to a considerable extent be controlled by the engineer . . . The perfection of technical improvements tending to the increased economy of operation of shipping . . . can only result in the more rapid obsolescence of tonnage not in conformity with the latest ideas."

This assistance towards the commercial recovery of his own business which the marine engineer can furnish, by putting forward claims so attractive that they cannot be neglected by the shipowner, has been chiefly in evidence during recent years in the development of the oil engine, but Mr. Richardson's chapter will remind the reader that advances have not been lacking in connection with the older steam engine. As coal is the only native fuel of this country any such advances are, and must be, of great interest to us. The latest developments in connection with steam raising for marine work are reviewed by Mr. Richardson. He deals with the de-aeration of feed water, mechanical stoking at sea, air preheating and the possibilities of using pulverised fuel. In spite of these possibilities, however, there is no question but that the main recent advances in marine machinery have been in connection with the development of the oil engine, and Mr. Richardson reviews the recent work, giving a list of the British manufacturers of large marine oil engines with the types they have specialised in. In this connection and when so many makers are building to some Continental design, it is matter of satisfaction to note that the two very promising types of opposed piston engines which are being manufactured are of British design and development. These two types, the Cammellaird-Fullagar and the Doxford, are now being built by 10 different firms. In connection with this question of the effect of technical improvement in the shipbuilding position mention may be made of the chapter on "The Shipowner and Research in Propulsion," by Mr. G. S. Baker, who gives some broad facts showing the economical effects of tank experiments on models of cargo ships.

Articles of special interest to shipowners are those on "The Work of the Tramp Steamer," by Mr. J. Howard Glover; "Sea Training of Merchant Seamen," by Captain Selwyn M. Day; "The Shipping Slump and the Value of Ships." by Dr. L. Isserlis; "The Low Costs of Sea Transport," by Mr. Cuthbert Maughan; "The Limit of Freight Depression," by Mr. R. W. Johnson; and "Shipping and Policy," by Mr. C. Ernest Fayle. It is not possible for us to deal in any way here with the contents of these valuable chapters which in themselves almost form a complete treatise on the present freight position. Other chapters we fear we must also dismiss with nothing but mention, such as those in "The Port of London," by Viscount Devonport, and "Wireless Direction Finding as an Aid to Navigation," by Mr. B. Binyon. Lord Devonport's chapter forms the first of a series which is to appear in Brassey each dealing with one of our great ports. The scheme is a good one, and the pages of this work form a very fitting place for such records. Mr. Binyon deals to some extent with the same subject as Dr. Eccles, but treats it from the point of view of the navigating offices.

"Brassey's Annual" is growing in size every year, and after attempting but the briefest review of the various articles it contains but little space is left to us to deal with the valuable reference sections which in all cover over 300 pages. These include the valuable and recently introduced feature of profiles of war and merchant ships (the section having been extended this year), lists of British and foreign warships, ordnance tables, reprints of the Washington and other treaties, and merchant shipping tables of various kinds. These sections contain valuable tabulated figures and much other matter of great value for reference, and it is difficult not to think that any one concerned with shipping affairs of any kind who has the book on his shelf will not reach it down many times in the course of a year. As usual, the volume contains an interesting and well-reproduced collection of photographs of new ships and machinery.

Cargo Handling at Ports: A Survey of the Various Systems in Vogue, with a Consideration of their Respective Merits. By BRYSSON CUNNINGHAM, D.Sc., B.E., M.Inst.C.E. London: Chapman and Hall, Limited. [Price 13*s.* 6*d.* net.]

DR. CUNNINGHAM'S book is evidently intended to be both descriptive and critical, but a very difficult task is undertaken when it is proposed to discuss the respective merits of the appliances provided for effective and economical cargo handling. Probably there is no best method. For what is a merit at one port may be an expensive inconvenience at another, and the cause of labour unrest at a third. Volume of imports and tidal variations will compel the adoption of particular appliances; custom of the port and organised training will determine the choice of methods; while the rules of trades unions and the antagonism of labour may go far to wreck ingeniously arranged schemes, that point to efficiency and speed in the handling of cargoes. It is obvious that attention should be centred on the provision of those appliances that secure the rapid loading and removal of cargo, that ensure safety to operatives and least damage to cargo, that reduce port charges and secure the largest volume of trade. The programme is very simple, but its execution is rendered difficult, and increasingly difficult, because as a rule on the dock quay labour is casual and irregular. Every man sees in the introduction of some labour-saving device, a scheme to deprive him of his chances of employment, increasing the bitterness of his poverty, and while the number of applicants is more than sufficient for the work forthcoming, argument is useless.

The description of apparatus is easier, and the author is doing valuable work in bringing under the notice of those who control the collection and despatch of cargo, alternative methods by which goods can be most competently handled. The information supplied concerning the arrangement of mechanism, and the comparison between schemes competing for public favour, affording ample indications of the directions in which the apparatus can be most usefully employed, make the volume

a very desirable guide to those engaged in port management.

Before attacking the more general aspect, some useful information is given on the classification of cargo and of the nature of the more simple appliances, such as those carried by ships, to be made available for handling cargo in ports inadequately furnished with quay side cranes and similar machinery. These remarks and suggestions should interest a larger circle than the experts, to whom the work is mainly addressed, though in these preliminary remarks some novelties are described that it is undesirable to miss. Particular reference may be made to an apparently effective apparatus designed by Mr. William Muller, of Amsterdam, who in the employment of masts and booms proposes to do away with the cumbersome use of two independent booms, and at the same time facilitate the swinging action of the single arm. The design appears judicious, but the point that arrested attention is the remark that the winch operator has a full view of the load which he can manipulate at will. By way of contrast, one might refer to the more elaborate and more powerful pedestal cranes, where the location of the operating cabin prevents the driver having a clear view of what is going on at the hook in all positions of the load, and resort is had to some form of signalling. The electrically-controlled gear which allows the driver to station himself at the hold and work the motors by suitable means is not altogether satisfactory.

The purely technical part of the book may be said to begin with the account of transit sheds, the shelter that provides accommodation of a temporary character to all cargoes whether inward or outward bound. A ship brings to the quayside a quantity of miscellaneous goods, which have to be discharged as rapidly as possible. A ship may have a quantity of cargo varying from 200 tons to 400 tons per linear foot, perhaps more in vessels of the largest carrying capacity, and if anything like this weight is dumped on the quay grave congestion is likely to follow, supposing the quay could carry such a burden. Fortunately no inconsiderable portion is put over the ship's side into lighters, some goes direct to rail, and to other means of transport, but in whatever way accomplished methods and skill are necessary, since evidently many complex and difficult situations arise. This is the tangle through which Dr. Cunningham warily conducts the reader. He creates the picture and then allows it to dissolve away as one appliance after another is brought into requisition. We have no intention of following him, though we would like to emphasise one point, the necessity of providing adequate and convenient road access to the docks. In the older ports, in the midst of densely-populated areas, it is practically hopeless to think that any material improvement can be made, while in the newer and presumably more carefully designed, it seems equally unlikely that adequate appropriation will be provided, so difficult is it to foresee future requirements and to make necessary provision. Dr. Cunningham asserts, and everyone who has had to do with dock traffic on a large scale will admit his accuracy, that he has seen long queues of vehicles remaining stationary, literally for hours, unable to make any progress by reason of overwhelming congestion in the road approaches to a dock. The addition to the port charges, per ton, on this account, must in some cases be very considerable, and such increased charges act as a handicap to the older ports, and is one that will increase with time. The greater facilities that improved mechanism supplies can do very little to remedy the inconvenience, for such devices only succeed in clearing the hatchways more speedily and consequently make the necessity of better transport more acutely felt.

It is not easy to do justice to these mechanical artifices; they are so numerous and the object to be effected by each varies very slightly. The development of the quay crane is interesting, and the improvements effected by the luffing motion of the jib promises to be both serviceable and economical of power. The luffing movement is intended to give an inwards and outwards motion in a straight line, as contrasted with the radial action of a fixed jib, There is less chance of contact with ships' yards and rigging when working within a limited space.

A form of handling cargo that has found wide application in America consists in the process of "burtoning," and the adoption of the method in opposition to that of quay cranes, general in Europe, illustrates the influence of national custom in designing and adhering to processes adapted to particular ends. In burtoning, the cargo-lifting hook is joined to the ends of two lines, and the load is swung between the vertical positions which the lines occupy at the extremities of their range. The swinging of booms or jibs is thus avoided. The load moves in a direct line and is lowered on to a precise spot. This is not altogether an advantage. If the depositing point is blocked, the gear is out of action until the place is clear. The quay crane, with its radial action, shows its superiority at precisely this point. Why burtoning should obtain on the western seaboard of America and the quay crane maintain its own in Europe, are points well worthy of discussion, and the author makes here a very interesting comparison between the two methods, to which we can only call attention. Having lifted the cargo from the hold, it becomes necessary to transport the goods short distances to a warehouse or to storing sheds, and to facilitate this process other types of apparatus are necessary, such as conveyors and elevators, which take many forms according to the nature of the work to be done. Amidst all the ingenuity displayed in gravity runways, slot conveyors, and other variations, it is curious and not uninstructive to read, that "the most convenient instrument for general purposes in goods stage operations, which has been found up to the present, is the human being behind an up-to-date hand barrow, so far as the large majority of existing goods depots is concerned."

Having dealt with miscellaneous cargoes in general, the author discusses the handling of cargoes of uniform character, as coal, a material, that by reason of its prominence in commerce, its weight and bulk, its carriage as cargo, and its treatment for bunkering, has demanded and received special attention to facilitate its distribution and accelerate its circulation. This increased attention is the more necessary, as distinct and important interests hamper, as well as assist, its transport. The colliery proprietors, the railway companies, the port authority, and the shipowner are each equally jealous of their interests and share a joint responsibility in maintaining the interests of commerce. The processes at every stage of transport are well described, and the illustrations of the machinery used in different ports form an adequate commentary on the text. Ore handling has, of course, much in common with that of coal. There is, however, one distinct difference in the possible application of electromagnetic methods to the lifting of ferruginous material. Magnets are constructed capable of lifting weights up to 200 tons, but for quay side work those of a much less powerful type are used, and seem to have a large field of usefulness in lifting iron of irregular shape and rough outline, making it difficult to handle. The author suggests that the influence of the magnetic field on the ship's compass is a disadvantage, but efficient screening could no doubt be provided, and the increasing use of the gyrostatic compass still further reduces the objection.

Grain cargoes, approaching as they do to liquids, that can be pumped out by suitable means, also call for separate treatment, more especially as some 80,000,000 tons are imported annually. Pneumatic tubes and suction apparatus are necessary to deal with grain cargoes in bulk, but the struggle with the bucket elevator and conveyor band is keen and strenuous. The latter method can be employed with smaller power consumption, but pneumatic schemes are growing in favour and with probable reduction of cost will find a wider application. As examples of pure pumping, we have the delivery of petroleum and fuel oils, which has originated a practically new industry. Cold storage and the increasing import of perishable food-stuffs have suggested new appliances. These are sufficiently well described, Dr. Cunningham confining himself strictly to the means of import, and not being concerned with the chemical apparatus that has made the transport of perishable articles possible over long distances.

No small fraction of the whole trade of the country is centred on sea transport, and the author has therefore a wide field to cover. He furnishes a picturesque and comprehensive glance over the whole conditions of sea-borne traffic, and though the details may fall short of what the expert needs, a very illuminating view of a large branch of industry is provided.

English for Engineers. By S. A. Harbarger. Department of English, Ohio State University. McGraw-Hill Publishing Company, Limited, London. 1923. [Price 10s. net.]

The title of this book is misleading, or rather we were led to misunderstand its object and the intentions of the author. By English, we understood, that wide reading and critical study of the best authors necessary for a literary training, and which is essential if the sympathies are to be kept wide and the mind receptive. Engineers for some reason have been selected more than once of late as a class, that particularly needs advice and assistance in the selection of good models, probably because it is concluded that attention to practical work has robbed them of some opportunities more favoured students enjoy. We do not think that engineers in the mass deserve this implied censure, or that their literary training and capacity is on a lower level than that of any other profession; nor do we believe it is just to say, that "bad English is responsible each year for more failures than inaccurate mathematical calculations." But we need not be at any pains to defend the literary ability of engineers, for the author's object is narrow and limited. We do not meet with any earnest appeal for the study of English for its own sake, for its educative and illuminating influence in widening outlook, for the cultivation of a balanced judgment, or for the possession of a wider experience. Up to the penultimate chapter, Mr. Harbarger considers the immediate uses to which English may be put by the engineer. By "immediate uses" is understood the artifices by which the young engineer may advance himself in his profession, how a knowledge of English may be turned to the greatest profit. An intensive study of English is urged as essential to business success, since it provides the power to present his professional ideas clearly and forcefully. The mercenary side is kept constantly to the fore, and the fact is deplored, that engineers have not been good salesmen. The engineer has not employed the best methods of marketing his ideas; he has failed to acquire the proper methods of reaching the customer in the market.

The volume, therefore, might have been more correctly entitled, "The art of advertisement for engineers," and looked at from that point of view it will no doubt prove satisfactory. It contains much good advice and shows how any one, provided he has time and aptitude, may be trained to express his ideas, accurately, briefly and tactfully. This implies carefully cultivated method and can be recommended to all. We do not understand the expression "the right attitude towards English" and we trust that the "mechanics of language" is the same as grammar, but we are willing to accept the author's aphorisms as a necessary part of the equipment of every business man, without the exclusion of other qualities. It may be observed that the qualities of clearness, conciseness, and emphasis are insisted upon, but no mention is made of exactness or truthfulness, yet these qualities are quite capable of being expressed in good terse English.

Passing from the general to the particular, we notice that our novice is taught how to write a letter, a "result-getting letter," that will bring business, not only by its accurate and cordial expression, but also by "general display and lay-out" for the exhibition of the contents is held to have the same importance in influencing the reader, that window dressing and decoration have in assisting a tradesman in the disposal of his goods. Of course, it is not intended to imply that there is anything wrong in this, but it suggests a new and elastic meaning to the term "English," to use it in describing what is purely a problem of presentation.

Other letters have, of course, to be written, letters of application soliciting employment, of inquiry, and of instruction, and on these the author discourses at considerable length. In the first the applicant sells, or endeavours to sell, his services, in others to sell his experience, or an idea, but the object in all is to secure pecuniary profit, profit is

always to the fore, and effort is directed to create the best market. Rarely is a desire to enforce the desirability of doing good sincere work for the work's sake to be seen in these letters. Superficiality of knowledge is recommended, if the gleanings from advertisements and magazine articles can be turned to account. But in using such crude and hastily acquired information a word of caution is given, advising the engineer to beware of professional terms, unless he is sure of their meaning. "He runs the danger of appearing ridiculous, if not insincere to his clients." The insincerity seems to consist in assuming a knowledge that is not possessed, but this view does not appeal to the author. The wisdom of the serpent, or at least of the experienced, is used to conceal and not to remove the deficiencies of the pupil. This intention is clearly shown in a chapter described as the "You-attitude," a term with which we were previously unacquainted, but is apparently used to express the effort to direct the needs and desires of the client, not necessarily to his own interests, but into a channel that ministers to the advantage of the applicant.

The unblushing selfishness written large on every page jars not a little, and we are glad to turn in a few chapters to something less personal, or at least to chapters in which the all-pervading dollar is not so evident. The advice on "General Professional" writing, including the preparation of abstracts, summaries, and reviews is sound, if at times obvious and certainly may be read with advantage by those whose duties or tastes oblige them to engage in literary work. Finally, we come to the chapter which we hoped would have been taken as the keynote of the book, since it insists on the study of English as the means of enlarging the interests of engineers in all human activities, of increasing the appreciation of all that is best in literature, and of communing with the master minds of all nations and ages. We are afraid there is a latent suggestion that the literature of recent date is all that need be considered. Shakespeare, it is true, gets a favourable notice, in connection with Barrie and Bernard Shaw, but time-honoured classics pass unmentioned.

In one of the many quotations given by Mr. Harbarger, to add authority to his utterance, may be read "Good books have to do with honour, fidelity and reverence. Books are bad when honour, fidelity and reverence are left out." The references the author makes to these qualities are few and unsatisfying.

BOOKS RECEIVED.

Organisation und Betriebsführung der Betontiefbaustellen. By Dr. Ing. A. AGATZ. Berlin: Julius Springer. [Price 0·85 dols.]

The Book of the Thorneycroft, showing how to Run and Maintain the War Office "J" Type and other Lorries Most Efficiently. By "AURIGA." London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Conférences de Chimie Minérale Faites à la Sorbonne (Metaux). By MARCEL GUICHARD. Paris: Gauthier-Villars et Cie. [Price 30 francs.]

Department of Overseas Trade. Report on the Economic Situation of the Nederlands East Indies to June, 1923. By A. N. BLUETT. London: His Majesty's Stationery Office. [Price 3*s.* net.]

United States Geological Survey. Professional paper, 132—A. *Rock Formations in the Colorado Plateau of Southeastern Utah and Northern Arizona.* By C. R. LONGWELL and others. Washington: Government Printing Office.

Lehrbuch der Eisenhüttenkunde. Vol. I. *Roheisenerzeugung.* By Dr. Ing. BERNHARD OSANN. Second edition. Leipzig: Wilhelm Engelmann. [Price 32*s.*]

Proceedings of the Rugby Engineering Society. Vol. XVI. 1921–22. Rugby: Offices of the Society. [Price 10*s.* 6*d.*]

Contribution à la Théorie des Moteurs à Combustion Interne. By M. BRUTZKUS. Paris: Gauthier-Villars et Cie.

Aeronautical Research Committee. Reports and Memoranda No. 860. *The Effect of Scratches and of Various Workshop Finishes upon the Fatigue Strength of Steel.* By W. NORMAN THOMAS, M.A., M.Sc. London: His Majesty's Stationery Office. [Price 3*s.* net.]

Lead. Its Occurrences in Nature, the Modes of its Extraction, its Properties and Uses, with some Account of its Principal Compounds. By J. A. SMYTHE, Ph.D., D.Sc. London: Longmans, Green and Co. [Price 16*s.* net.]

Elementary Aeronautical Science. By IVOR B. HART, D.Sc., and W. LAIDLER, B.Sc. Oxford: The Clarendon Press. [Price 7*s.* 6*d.* net.]

The Supervision and Maintenance of Steam-Raising Plant. By CHARLES A. SUCKAN. London: Ernest Benn, Limited. [Price 36*s.* net.]

Mechanical Stoking. A Practical Treatise on the Essentials of Machine Stoking, and the Construction and Operation of Mechanical Stokers. By DAVID BROWNLIE, B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 5*s.* net.]

A System of Plan Copying in Black Lines suitable for Use in Hot Countries. By B. J. HALL, M.I.Mech.E. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

A Treatise on Electro-Metallurgy; Embracing the Application of Electrolysis to the Plating, Depositing, Smelting and Refining of Various Metals, and to the Reproduction of Printing Surfaces and Art Work, &c. By WALTER G. MCMILLAN. Revised by W. R. COOPER, M.A., B.Sc., A.I.C. Fourth edition, revised and enlarged. London: Charles Griffin and Co., Limited. [Price 21*s.* net.]

Kent's Mechanical Engineer's Handbook. By the late WILLIAM KENT, M.E.Sc.D. Tenth edition re-written by ROBERT THURSTON KENT, M.E. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 35*s.* net.]

The British Journal Photographic Almanac and Photographers' Daily Companion, 1924. Edited by GEORGE E. BROWN, F.I.C. London: Henry Greenwood and Co., Limited. [Price 3*s.* net.]

University of Illinois, Engineering Experiment Station. Bulletin No. 137. *The Strength of Concrete, its Relation to the Cement Aggregates and Water.* By ARTHUR N. TALBOT and FRANK E. RICHART. Urbana: University of Illinois. [Price 60 cents.]

Industriebetriebslehre. By Dr. Ing. E. HEIDEBROCK. Berlin: Julius Springer. [Price 4·20 dols.]

Kolben. I. *Dampfmaschinen und Gebläsekolben.* By Dipl. Ing. C. VOLK. II. *Gasmaschinen-und Pumpenkolben.* By A. ECKARDT. Second edition, revised by C. VOLK. Berlin: Julius Springer. [Price 0·90 dols.]

In der Luft unbesiegt. Erlebnisse im Weltkriege. By GEORG P. NEUMANN. Munich: J. T. Lehmanns. [Price 5*s.*]

Board of Trade. Regulations Relating to the Examinations of Engineers in the Mercantile Marine. London: His Majesty's Stationery Office. [Price 6*d.* net.]

Modern Mechanical Engineering. A Practical Treatise. Edited by A. H. GIBSON, D.Sc., M.Inst.C.E., M.I.Mech.E., and ALAN E. L. CHORLTON, C.B.E., M.Inst.C.E., M.I.Mech.E. In six volumes. Vol. I. *Drawing Office Organisation, Pattern-making, Foundry Work, The Machine Shop, Fitting and Erecting of Heavy Machinery.* Vol. II. *Transport of Heavy Machinery, Pipe Work, Applied Mechanics, Elasticity and Strength of Materials, the Testing and Properties of Materials.* Vol. III. *Hydraulics, Modern Pumping Machinery, Fans and Air Compressors, Hydraulic Machinery, Water Turbines, Refrigeration.* Vol. IV. *Mechanism, Machine Drawing and Design, Rivets and Riveted Joints, Applied Heat, Steam Boilers.* Vol. V. *Coal and Ash-Handling Plant, Engineering Chemistry, the Reciprocating Steam Engine, Steam Turbines, Condensers and Cooling Towers; the Operation of Land Power Plants.* Vol. VI. *Gas Engines, Oil Engines, Motor Cars, Aero Engines, Gas Producers, the Operation of Oil Engines, the Operation of Gas Engines.* London: The Gresham Publishing Company, Limited. [Price 84*s.* net.]

Ponts et Combles Métalliques. By T. GODARD. Paris: J. B. Baillière et fils. [Price 60 francs.]

Railway Amalgamation in Great Britain. By W. E. SINNETT. London: *The Railway Gazette.* [Price 15*s.* net.]

The Highway Engineer's Year Book, 1924. Edited by H. GILBERT WHYATT, M.Inst.C.E. London: Sir Isaac Pitman and Sons, Limited. [Price 6*s.* net.]

Bildtelegraphie. By DR. ARTHUR KORN. Berlin and Leipzig: Walter de Gruyter and Co.

Engineering Drawing. By H. H. JORDAN, B.S. and R. P. HOELSCHER, B.S. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 15*s.* net.]

Elementary Steam Power Engineering. By EDGAR MACNAUGHTON, M.E. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 25*s.* net.]

Technical Writing. By T. A. RICKARD. Second edition rewritten and enlarged. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 10*s.* net.]

Oil Engines. By A. L. BIRD, M.A. London: Methuen and Co., Limited. [Price 12*s.* 6*d.* net.]

AMERICAN COKE AND PIG IRON.—We read that what is believed to be a world's record for coke production per oven per day has been made at the new by-product coke plant at the Weirton Steel Company, Weirton, W.Va., says *The Iron Age,* New York. This plant, consisting of 37 Koppers Becker type ovens, has been operating continuously on a coking time of less than 11 hours 30 minutes carbonising over 1,060 tons of coal per day, or approximately 29 tons per oven per day, with excellent by-product recovery. The total coke produced averages more than 775 tons per day, and the by-product yields per ton of coal carbonised have averaged 13·5 gallons of tar, 24 lb. of ammonium sulphate and 4 gallons of light oils. The total gas yield is approximately 11,400 cub. ft. of 555 B.Th.U. debenzolised gas per ton of coal carbonised, of which 65 per cent. is surplus gas available for use in the steel plant. The coal used is straight high volatile from the Pittsburgh district, no low volatile coal being used. With this coke the furnace produced an average of 610 tons of pig-iron per day without using any scrap and with a lower coke consumption per ton than when using beehive coke. This establishes a world's record in pig-iron production for one furnace when using straight Lake ores and coke made from 100 per cent. high volatile coal in by-product ovens.

SOCIETY OF GLASS TECHNOLOGY.

THE president, Professor W. E. S. Turner, D.Sc., presided at the meeting of the Society of Glass Technology held in University College, Gower-street, London, W.C. 1, on Wednesday, December 12, at 2.30 p.m. Three papers were presented, namely: (*a*) "*An Apparatus for Calibrating Burette Tubes,*" by Verney Stott, B.A., F.Inst.P. The method of calibration used was that of transferring successive quantities of water from the blank burette tube to a standard pipette. A piece of thermometer tubing was attached to the top of the burette tube by means of two pieces of rubber tubing and an adapter. The thermometer tubing controlled the rate at which air entered the top of the burette tube and therefore controlled the rate of outflow of water from the burette tube. The pointing marks were made by folding a piece of black paper round the burette tube, and fastening it with seccotine so that the top edge of the strip coincided with the bottom of the water meniscus. Details of the apparatus and its use were described.

(*b*) "*Some Factors Affecting Efficiency in the Glass Trade,*" by Mr. Eric Farmer, M.A. (Industrial Fatigue Research Board). The special problem discussed was the relative efficiency of different methods of dividing the working day. The investigation was carried out mainly in the Yorkshire district where a change from the two-shift to the three-shift system had recently been made. The plan adopted was to select bottles which had been made for a lengthy period by the same "chairs" under both methods of subdividing the working day. It was found that the hourly output of the 8-hour shifts was practically in all cases greater, in the hand-made process, than that of the 10-hour shift. The increase was more marked in the case of large bottles than in the case of small bottles. With semi-automatic processes the results were the same. Corroboration was not obtained of the general opinion held in the glass trade that output was uniformly affected by hot weather. The effect of bad temperature conditions was cumulative and so tended to increase fatigue as the day went on. It was found that the morning shift was always the least efficient throughout the year, and this inefficiency was particularly marked during the heat of summer. There was little difference between the afternoon and the night shifts, though on the whole, the night shift was less efficient than the afternoon shift. The effect of rest pauses was well-known, but all stoppages of work were not so beneficial. The effect of stoppages due to the coal strike and the influenza epidemic was to lower efficiency, owing to loss of motor dexterity on the part of the workers.

(*c*) "*Specifications in the Glass Industry, with Specia Reference to Soda Lime Glasses for Glass Containers,*" by Professor W. E. S. Turner, D.Sc. The subject had received emphasis owing to recent occurrences involving the interests of both the general public and glass manufacturers and users. In some branches of the glass industry specifications had been employed, or at any rate, some approach to standards had been made, for example, optical glass must possess a specific refractive index and dispersion. In the very important soda-lime glasses for containers, little had as yet been attempted in the way of specifications. There were two or three kinds of tests or specifications which might be applied, namely, specifications as to (*a*) competition, (*b*) use, (*c*) tests. For glass containers, there were two essentials—(i) durability, and (ii) a satisfactory state of annealing. Glass for common containers should contain not more than 18 per cent. of sodium oxide in the finished glass, and not less than 8 per cent. of lime or calcium oxide. The conditions for annealing varied with the composition of the glass and could not be specified. There were, however, definite methods of testing glassware for strain, so that manufacturers and users might exercise control over their products or purchases. Specifications were then considered, for (*a*) medicine and drug containers, (*b*) beer and spirit bottles, (*c*) jam jars, (*d*) potted meat jars. The points to which particular attention had been paid were not the only ones the purchaser must consider. He would obviously take into account also such matters as correct capacity, freedom from sharp edges, and satisfactory colour or absence of colour.

COAL IN BELGIAN CONGO.—As stated in the *Revue Universelle des Mines,* Liége, two coal beds have been discovered in Belgian Congo, both in Katanga. One was traced in 1910, close to Lake Tanganyka, by the Société Géomines, the second was found in 1914 on the Luena, near Bukama, by the same company. In the former there are at least five regular seams varying in thickness from 31 in. to over 70 in., and it is expected to yield over 1,000,000,000 tons. The second bed is of less importance and is expected to yield about 10,000,000 tons, but it is close to the copper mines of the district.

THE LATE MR. P. J. MARSHALL.—A member of the well-known family of engineers in Gainsborough, Mr. Percy J. Marshall, died with great suddenness from heart failure on Monday night, December 17, at his home, Knaith Hall. His health has not been good for some time, but recently he showed marked improvement and was able to take part in the activities in connection with the recent election. He retired some years ago from active participation in the management of Messrs. Marshall, Sons and Co., Limited, for which he was at one time in control of the Trent Works. He is remembered for his prowess in sport, and he did much to foster the growth of athletic pursuits among the workers of the firm.

6,600-VOLT STEEL FRAME SWITCH GEAR.

CONSTRUCTED BY MESSRS. GEORGE ELLISON, ENGINEERS, BIRMINGHAM.

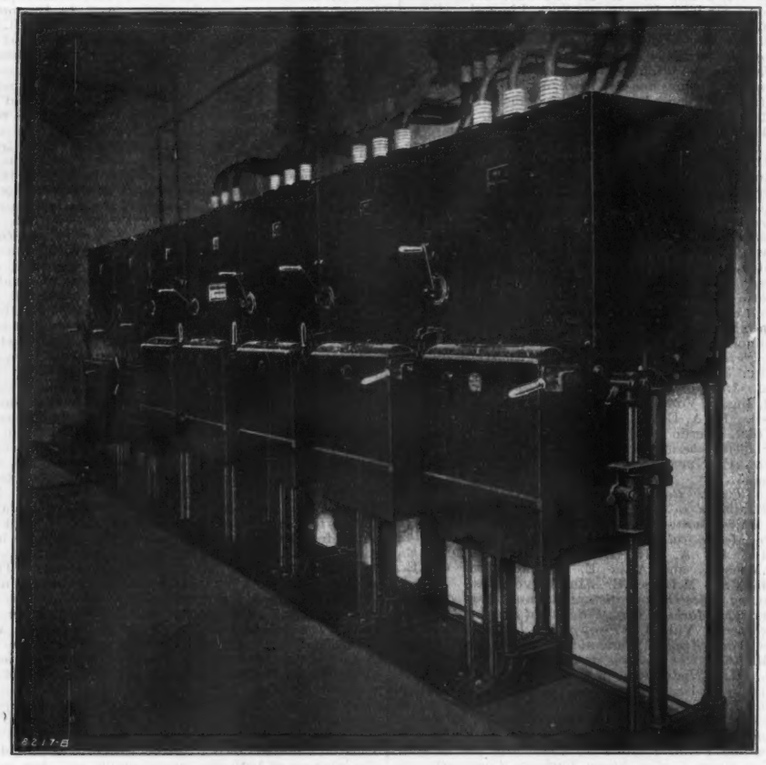


Fig. 1.

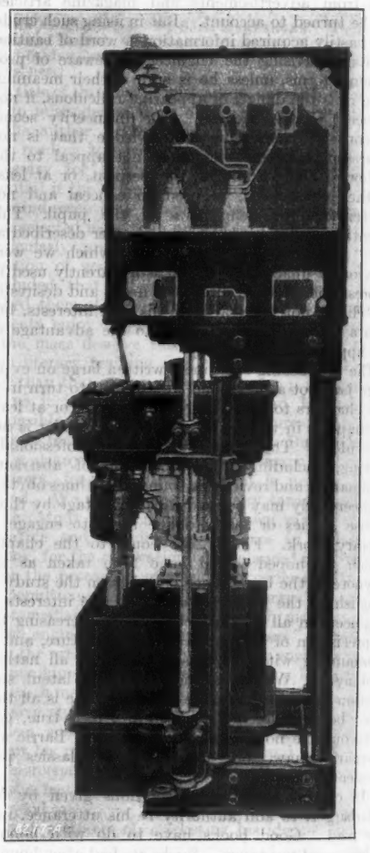


Fig. 2.

A new type of three-phase ironclad high-tension switch-gear which is being introduced by Messrs. George Ellison of Perry Bar, Birmingham, is illustrated in Figs. 1 and 2 above. The gear, which is intended for a maximum voltage of 6,600, has been expressly designed to occupy the minimum floor space, and to ensure this the oil circuit breaker is arranged to lower down when it is desired to remove it from all contact with high-tension connections for examination, or attention to the oil in the tank. This arrangement obviously demands less floor space than the more common one in which the switch is pulled forward into the passage in front of the gear. In many cases it is necessary to install high-tension distributing switchboards in existing buildings and works in situations which have not been designed for them, and the small amount of space demanded by this gear should make it specially suitable for many of the somewhat difficult cases which arise. An example of an actual installation of the gear is given in Fig. 1, which shows the board in the Northfield sub-station of the Birmingham Electric Supply Department.

As will be seen from the illustration of this Northfield board in conjunction with the view of a single unit of the gear given in Fig. 2, the arrangement consists of a bus-bar chamber constructed of angles and steel plate and carried on a series of vertical tubular members which are provided with cast-iron feet. In front of each set of four tubular members, which support a single unit of the gear, there are two vertical screws, which can be rotated through a gear operated by a handle at the left-hand lower corner of the bus-bar section of the unit. The rotation of these screws lowers the switch as a whole until it is completely disconnected from all high-tension gear, and after this lowers the oil tank independently so that the contacts are exposed.

In the unit illustrated in Fig. 2 the switch and oil tank have been lowered to their bottom position. As will be seen from this figure the bus-bar chamber is divided horizontally into two parts, the upper part forming the bus-bar chamber proper. The lower part is an isolating plug chamber and contains a series of insulators carrying plugs which make contact with the oil switch terminal stems when the switch is in the top position. As the switch is lowered the plugs are withdrawn and the switch is rendered dead. An insulating slide operated by the oil-switch lowering mechanism slides over the ends of the insulating tubes which the switch terminal stems enter when in their top position, so that when the switch is lowered no live metal is exposed. The lowering mechanism is interlocked with the oil-switch operating handle, so that the switch cannot be lowered unless it is in the open position and the circuit consequently cannot be broken on the isolating plugs.

The bus-bars are round copper rods covered with insulating tubes and carried by porcelain insulators from the roof of the bus-bar chamber. All connections to the bus-bars are taped over after being made and insulating screens are provided between each section of the chamber. The isolating plugs are carried on porcelain insulators mounted on the horizontal partition which divides the bus-bar chamber from the isolating plug chamber. The whole arrangement will clearly be understood from Fig. 2. It will also be gathered from this figure in conjunction with Fig. 1 that the outgoing cables from the oil switch which connect on to the front row of isolating plug insulators are taken through porcelain bushes in the top of the bus-bar chamber. As will be clear from Fig. 2, the arrangement lends itself to a very neat lay-out. The gear, as will be seen, is simple and straightforward. The trip coils of the oil switch are in the main circuit, and no attempt has been made to arrange for the mounting of either current or potential transformers in the units. There is always a temptation in getting out a gear of this kind to attempt to make it suitable for the mounting of all sorts of combinations of instruments and switch controls. This type of endeavour always leads to complication and a less effective arrangement for the simple overload type of panel which represents by far the major part of the applications of practice, and Mr. Ellison is to be congratulated on having maintained the initial simplicity of his gear.

The maximum current-carrying capacity of the oil switch is 250 amperes, which is probably much above the requirements of the average application. When run at this current the isolating plugs carry 86 amperes per square inch of contact surface, and the brushes 180 amperes per square inch of contact surface. The length of travel of the moving contact of the switch is 3½ in., and the length of clear break 3 in. The speed of break is 5 ft. per second. The head of oil is 8½ in. The oil tank is made from ¼ in. plate welded at the seams and reinforced by a band, 1 in. square, welded on at the level of the arc. The overload coils are in the oil tank and have about 2½ in. head of oil above them. The coils are wound on bobbins made of two concentric tubes of reinforced synthetic resin with end flanges of the same material, the flanges and tube walls being ¼ in. thick. The winding is covered with tape, and the whole arrangement is impregnated with synthetic resin and baked. The coils are capable of standing the full pressure test in air. The overload coils may be fitted, and space is available for a fourth no-volt coil, but as the gear contains no accommodation for transformers, such a coil can only be fitted when low-tension current is available from an external source, as, for instance, from the secondary of a power transformer protected by the panel.

Electro-Chemical and Electro-Metallurgical Industries in Switzerland.—During the year 1922 the exports of calcium carbide from Switzerland which had, during the war, risen from 7,000 tons in 1913 to 75,000 tons in 1918 and rapidly declined afterwards, showed a further decrease; the country itself absorbed in 1922 about 2,500 tons of the total of 12,000 tons of carbide produced. The cyanamide works in Martigny had produced 40,000 tons during the last war year; that production had also decreased, but was increasing again, mainly owing to exports to France of phosazote (6,000 tons in 1922), which is a compound of cyanamide and calcium superphosphate. Other products of calcium carbide, acetaldehyde, alcohol, acetic acid metaldehyde (a fuel) are said to be doing fairly well. The aluminium production had reached 11,370 tons in 1918; and rose last year. The production of iron alloys is declining; for ferro-silicon the production figures were, in the years 1913, 1917, 1922, respectively 16,180 tons, 22,780 tons and 2,610 tons; the electro-cast-iron works in Bex have been shut down. High alumina-cement is a new promising product, but the raw material, bauxite, has to be imported. The nitrogen fixation process of the nitric acid works in Chippis is not proving a financial success, and the electrolytic alkali, sodium, chlorine and chlorate works do not seem to be very prosperous either.

EXHAUST-VALVE AND CYLINDER-HEAD TEMPERATURES IN HIGH-SPEED PETROL ENGINES.*

By Professor A. H. GIBSON, D.Sc., Member, and H. WRIGHT BAKER, M.Sc., of the University of Manchester.

DURING the past five years the authors have had the opportunity of measuring the exhaust-valve temperatures in a number of high-speed petrol engines under different operating conditions. A number of these tests were carried out on the cylinders of aero-engines during the development work at the Royal Aircraft Establishment, and these have been largely extended by the results of an investigation in the Engineering Department of the Manchester University on a single-cylinder water-cooled unit presented by Messrs. Armstrong-Siddeley Motors, Limited. A fairly comprehensive series of tests of exhaust-valve temperatures has been made on this engine, along with measurements of cylinder-head temperatures. The results of these, and of a series of measurements made on aero-engine cylinders fitted with water-cooled exhaust valves, form the subject of the present paper.

* Paper read before the Institution of Mechanical Engineers on Friday, December 14, 1923.

CYLINDER (a) WITH ALUMINIUM HEAD & STEEL BARREL. CYLINDER (b) WITH MODIFIED HEAD & BARREL.

Fig.1 (a).

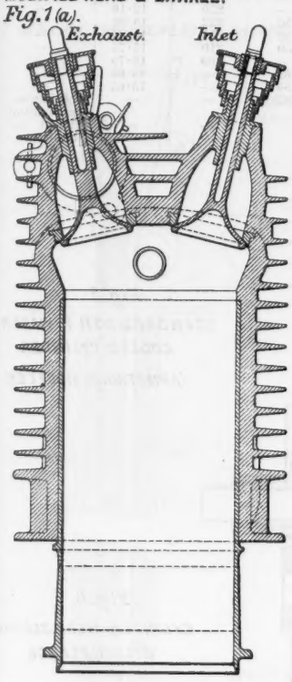


Fig.1 (b).

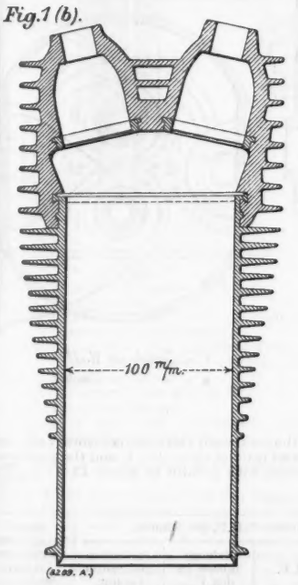


Fig.2. CYLINDER (b). ALUMINIUM HEAD & STEEL BARREL.

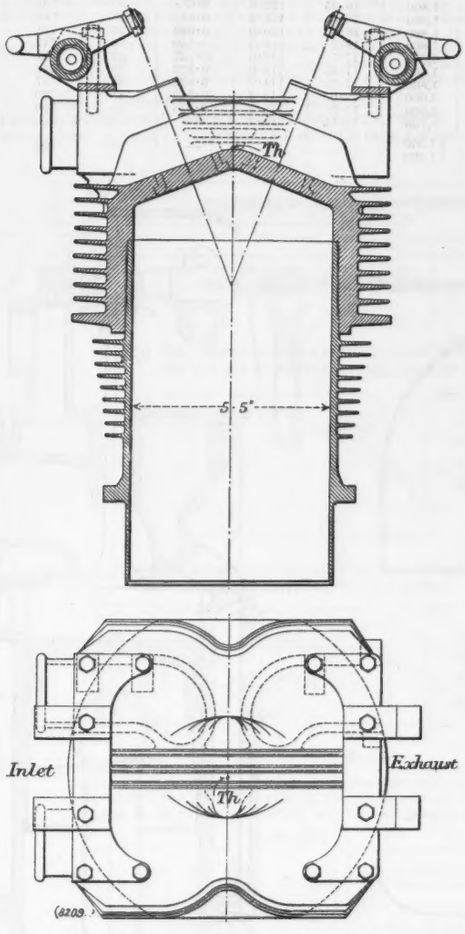
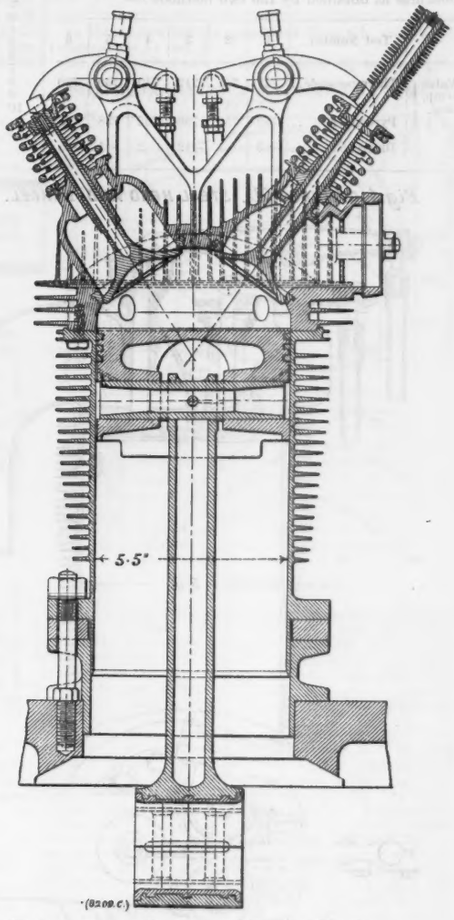


Fig.3. CYLINDER (c). ALUMINIUM HEAD AND STEEL BARREL.



The tests made at the Royal Aircraft Establishment were generally made under full-load conditions, at normal speed, but with varying mixture strengths, with the object of ascertaining whether the valve cooling was likely to be satisfactory under the most trying operating conditions.

On the Armstrong-Siddeley unit two cylinders have been tested. One of these was made to the drawings of the cylinder used in the 1920 standard 30 h.p. six-cylinder Armstrong-Siddeley car. It was, however, provided with alternative sparking-plug positions, and with facilities for varying the compression ratio, the valve-lift, and the position of entry and exit of the cooling water. The other cylinder differed only in the position of the valve-ports, which, as cast, prevented free access of water to a large portion of the cylinder head. The comparison of tests on these two cylinders is of interest as indicating the relative effect on valve temperatures and on general performance, of a well-cooled and of an indifferently-cooled head. The tests have been designed with a primary view to determine the effect on the exhaust-valve temperature of the following variables :—

(1) Strength of working mixture.
(2) Power output.
(3) Compression ratio.
(4) Speed.
(5) Spark advance.
(6) Cylinder-jacket water temperature.
(7) Position of admission of cooling water to cylinder-jacket.
(8) Shape of valve.
(9) Width of valve-seat. Cooling effect of valve-seat and guide.
(10) Lift of valve.
(11) Valve tappet clearance.
(12) Type of fuel. (Petrol and 20 per cent. benzol-petrol mixture.)

(2) *Details of Cylinders.*—The details of the cylinders tested, all of which are of the overhead-valve type, are given in the annexed table.

(3) *Experimental Apparatus.*—In all the tests, the brake horse-power was measured by a Froude hydraulic brake. In the tests at the University, and in a number of the tests at the R.A.E., the air-petrol ratio was deduced from air-box measurements, for which Watson's orifice coefficients have been used.* The petrol consumption was regulated by a Claudel-Hobson carburettor fitted with a simple needle-adjusted jet. Variations in the compression ratio were effected by the insertion of packing pieces between the cylinder and crank case. In the tests on the water-cooled cylinders, cooling water was supplied from the town's mains. This first circulates through a jacket surrounding the exhaust pipe and through a calorimeter for extracting heat from the exhaust gases, which consists of a nest of 24 brass tubes, $\frac{3}{8}$ in. diameter and 19 in. long, with the water circulating outside the tubes. After leaving the calorimeter, the water passes to the cylinder jackets, and from there to the jacketed induction pipe. During tests to determine the effect of a variation in the jacket-water temperature, the latter jacket was cut out of the circuit. Three positions of the jacket-water inlet have been used in the course of the investigation.

* Proc. I.Mech.E., 1912, page 517.

Particulars of Cylinders Tested.

Cyl.	Bore.	Stroke.	Type.	Exhaust Valves. No.	Exhaust Valves. Diam. in Port.
a	100 mm.	140 mm.	Aluminium head and steel barrel —air - cooled (Fig. 1*b*).	1	42 mm.
b	5·5 in.	6 in.	Ditto (Fig. 2).	2	1·5 in.
c	5·5 in.	6·5 in.	Ditto (Fig. 3).	1	2·3 in.
d	5·5 in.	6·5 in.	Steel head and barrel — air - cooled (Fig. 4).	2	1·7 in.
e	3·5 in.	5·25 in.	Armstrong - Siddeley Standard 30 h.p. water-cooled (Fig. 5).	1	1·425 in.
f	3·5 in.	5·25 in.	Armstrong - Siddeley with modified head cooling.	1	1·425 in.

In the tests at the R.A.E., the fuel was Shell aviation spirit, while in the University tests Pratt's No. 1 motor spirit (sp. gr., 0·724 at 15° C.) was used, except in a series of comparative tests when the fuel consisted of a mixture of 80 per cent. petrol and 20 per cent. benzol.

(4) *Measurement of Exhaust-valve Temperatures.*—The measurement of the mean temperature of the head of the exhaust valve of a high-speed petrol engine is a matter of some difficulty. Several attempts to do this, using platinum-iridium thermo-couples inserted into the valve head through the hollow valve stem, were made at the Royal Aircraft Establishment during experimental tests on single-cylinder units, but these failed owing to lack of mechanical strength to resist the large inertia

forces. After many attempts the type of thermo-couple shown in Fig. 7 was devised and used with success.*

Owing to the impossibility of using thermo-couples in the valves of engines undergoing routine tests, it was decided to use the results of the tests on this installation to test the accuracy for measurement of valve temperatures of the type of optical pyrometer known as the "Pyromike." In these tests the engine was run with open exhaust, and the pyrometer was sighted through the exhaust port on to the upper side of the valve head at a point midway between the stem and the edge of the valve. Under normal conditions this is the hottest point, the periphery of the valve, being cooled by contact with the seat, usually running black in a well-cooled engine. The following table shows comparative temperatures as obtained by the two methods :—

—	Test Number.	1	2	3	4	5	6
Valve temp. deg. C.	Thermo-couple..	747	751	742	760	759	790
	Pyrometer ..	750	752	730	762	758	785
	Difference ..	+3	+1	−12	+ 2	−1	−5

The general results of the tests were such as to indicate that with care the instrument is capable of giving exhaust-valve temperatures which are probably within 10 deg. C. of being accurate.

For the tests at the University a "Shore" pyroscope was used. With this instrument the intensity of the light radiated from the heated exhaust valve is matched with the light intensity of a standard paraffin flame modified at will by the use of a calibrated iris diaphragm of red celluloid. The pyroscope was calibrated before use against a standardised thermo-couple inserted in a block of steel in an electric furnace, the readings of the two instruments varying, on the average, by only about 3 deg. C. The "black body" conditions necessary for accurate readings were provided by the position of the valve, the back of which was viewed through a ¼ in. opening in the side of the exhaust pipe.

Under these conditions the temperature readings could be repeated at any time with reasonable accuracy. It will be noted that comparatively few points on the valve-temperature diagrams lie more than 10 deg. C. from the mean smooth curves.

(5) *Measurement of Cylinder-head Temperatures.*—For the determination of cylinder-head temperatures thermo-couples of copper-constantan (Fig. 8) were used. These were screwed into the metal walls from inside the cylinder, after which the heads were ground down flush with the walls. Good metallic contact was ensured by tinning the head of the couple with solder having a high melting point. The wires, insulated by enamel or double silk winding, were led through the water space in small-bore rubber tubes, and where these passed through the jacket walls the water joint was made by a rubber-packed gland. A common cold junction was provided in an ice flask. A number of couples were also placed in the water space, and one in the exhaust-valve guide.

* This design is due to Mr. D. Heron.

TABLE I.

Test No.	R.P.M.	B.H.P.	B.M.E.P. Pounds per sq. in.	Petrol Consumption. Pints per B.H.P.-Hr.	Spark Advance.	Valve Temp. by Thermo-Couple.	Valve Temp. by Optical Pyrometer.	Temp. at Centre of Cylinder Head.	Air to Petrol Ratio by Weight.	Remarks.
					Deg.	Deg. C.	Deg. C.	Deg. C.		
1	1,800	18·65	122·5	0·688	30	706	—	207	11·1	—
2	1,800	18·5	121·3	0·648	30	715	—	218	11·85	—
3	1,800	18·4	120·9	0·636	30	724	—	220	12·16	—
4	1,800	18·2	119·5	0·566	30	747	750	222	13·83	—
5	1,800	17·7	116·0	0·527	33	751	752	214	15·25	—
6	1,800	17·35	114·0	0·522	38	742	730	210	15·75	—
7	1,800	17·35	114·0	0·522	38	747	—	209	15·75	—
8	2,000	19·0	112·3	0·515	38	760	762	—	15·65	—
9	2,000	19·0	112·3	0·515	38	759	758	—	15·65	—
10	1,700	12·15	84·4	—	38	790	785	—	—	Continuous pre-ignition.
11	1,500–1,900	—	—	—	33	805	—	—	—	Violent pre-ignition.

Fig. 4. CYLINDER (d). STEEL HEAD AND BARREL.

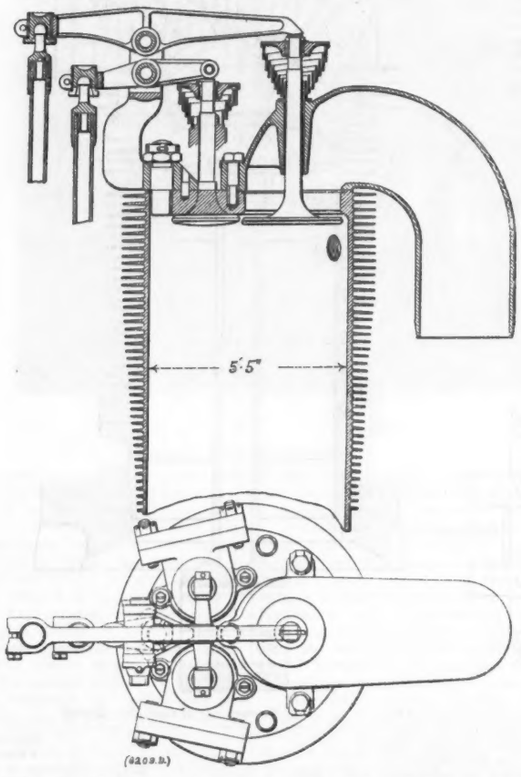


Fig. 5.
STANDARD 30 H.P. WATER COOLED CYLINDER (ARMSTRONG-SIDDELEY)

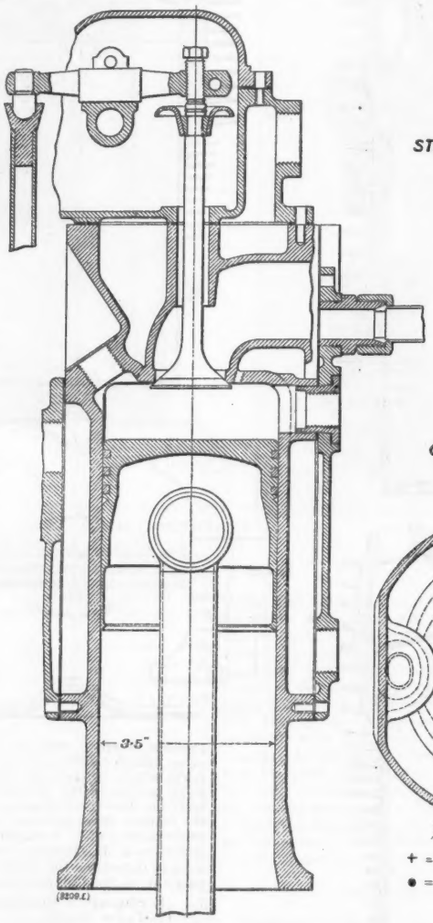
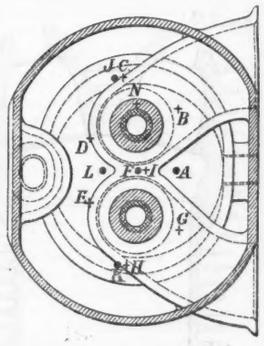


Fig. 6.
CYLINDER-HEAD SECTION BELOW FLANGE



+ = *Couple in Wall*
● = " *Jacket*

The general arrangement of the couples is indicated in Figs. 5 and 6, the couples in the walls being indicated by a +, and those in the water space by a black dot.

(6) *Experimental Data—Air-cooled Cylinders.*—(*a*) *Single Aluminium Air-cooled 100 mm. Bore Cylinder* (Fig. 1). These tests were carried out with a compression ratio of 5·5 at 1,800 r.p.m. and 2,000 r.p.m. over a wide range of air-petrol ratios. The air temperature was 19 deg. C., the velocity of the cooling wind 62 m.p.h., and the barometer 29·65 in. The optical readings of valve temperatures were taken at point A, Fig. 7. In each case the spark advance was adjusted so as to give maximum power without detonation. The results of the tests are shown in Table I, and the effect of a variation in the air-petrol ratio, and in the consumption per brake horse-power, is shown in the curves of Fig. 9 (*a*) and (*b*).

In this case the maximum valve temperature is attained with an air-petrol ratio of about 15 : 1, and the maximum head temperature with a ratio of about 13·5 : 1. The reason for the former effect is apparent from the figures in Table II, which are taken from tests on the same cylinder at a compression ratio of 5·0.

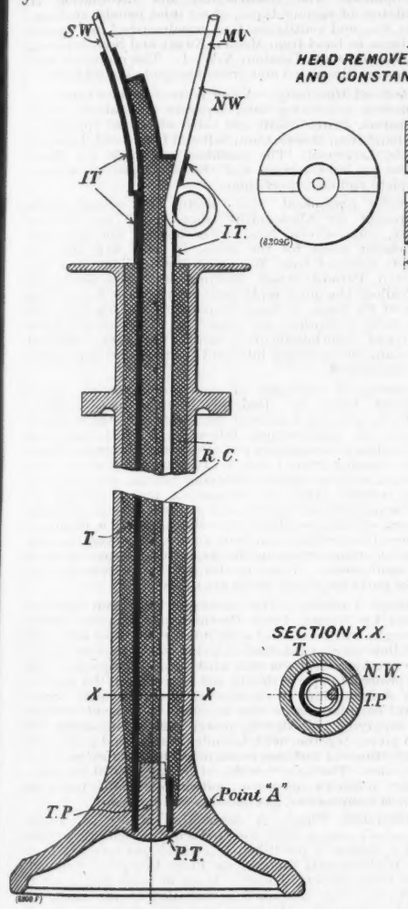
Each pair of tests was run at full throttle under identical conditions, except that the petrol supply in Tests 1 and 3 was adjusted to give the weakest maximum-load

TABLE II.

Test.	R.P.M.	B.H.P.	Petrol. Pounds per B.H.P.-hour.	Air-petrol Ratio.	Heat Distribution C.H.U. per Minute.				Mean Temperature of Cylinder Cooling Surfaces.
					Unburnt Petrol.	B.H.P.	Exhaust (above 15 deg. C.).	Radiation and Piston Cooling.	
									Deg. C.
1	1,800	16·2	0·544	13·6	219	382	478	442	119
2	1,800	15·1	0·516	14·9	39	356	551	388	113
3	2,000	16·1	0·535	14·0	143	379	519	416	115
4	2,000	15·3	0·523	15·0	24	359	615	382	110

mixture; while in Tests 2 and 4 it was further reduced so as to give approximately the maximum thermal efficiency on the brake. In these tests the heat in the exhaust gases was obtained by means of a calorimeter, the temperature of the gases leaving the calorimeter being measured by thermometer. The figures show that the heat rejected per minute in the exhaust gases, measured above air temperature (15 deg. C.), is in each case greater with the weaker mixture, being 15 per cent. greater in Test 2 than in Test 1, and 19 per cent. greater in 4 than in 3. The data show that the weight of exhaust gas per minute is 4 per cent. less in 2 than in 1, while in 3 and 4 the weights per minute are identical within 0·5 per cent. From this it appears that in each pair of tests the exhaust temperature, measured above 15 deg. C., is 19 per cent. higher with the weaker mixture, which indicates that the temperature is in each case approximately 200 deg. C. higher.

Fig. 7. GENERAL ARRANGEMENT OF THERMO-COUPLE



S.W. Steel wire soldered to M.S. tube.
I.T. Insulating tape.
T. 0·25-in. O.D.M.S. tube, half cut away and notched to hold cement.
T.P. Taper M.S. plug expanding tube into valve head and "nichrom" wire into tube.
M.V. To milli-voltmeter.
N.W. "Nichrom" wire 18 S.W.G.
R.C. Refractory cement.
P.T. Plug tube and "nichrom" wire welded together into valve head.

From Table I it appears that the temperature of the cylinder head (measured at the centre of the head) only varies slightly with the air-petrol ratio, and this is confirmed by the figures given for the mean temperature of the cooling surfaces, including the cooling fins, given in Table II. Under normal conditions the valve temperature is 15 deg. higher in this cylinder at 2,000 than at 1,800 r.p.m. With the cooling wind cut down until continuous pre-ignition takes place, the temperature rises to 805 deg. C. Under such conditions a tungsten steel valve scales badly and rapidly burns out.

Tests on a similar cylinder in which the exhaust-valve seat was loose gave valve temperatures of 810 deg. unaccompanied by pre-ignition. In this case the valves, of tungsten steel, burned out after about one hour's operation on full throttle.

(b) Single Aluminium Air-cooled 5½ in. by 6 in. Cylinder (Fig. 2).—These tests were carried out with a compression ratio of 5·05, at 1,700 r.p.m., with an air temperature of 17 deg. C.; a wind speed of 70 m.p.h., and a barometer of 29·83 in. The results are shown in Table III. In this cylinder, valve No. 1 was always hotter than No. 2 This is partly due to the direction of the cooling blast, and partly to the fact, discovered after the tests, that valve seat No. 1 was slightly loose in the aluminium cylinder head.

Tests Nos. 1–5 show the effect of a continuous reduction in the strength of mixture in increasing the valve temperature. The cylinder-head temperature T_A was measured by thermo-couple at the point marked in Fig. 2. It will be noted that the temperature range at this point is not great, and that the maximum is attained with a mixture stronger than gives the maximum valve temperature.

Test 6 was carried out to determine the effect of a variation in the position of the sparking plugs. The cylinder is provided with four plug holes in pairs diametrically opposite and adjacent to the four valves. In each test two diametrically-opposed plugs were used. In Tests 1–5 the diametrical plane containing them also passes through exhaust valve No. 1, so that one plug is

Fig. 8. THERMO-COUPLE HOT JUNCTION. HEAD REMOVED BY GRINDING AFTER INSERTION. WIRES: COPPER AND CONSTANTAN 30 W.G, INSULATED AND BRAZED TO M.S. BODY.

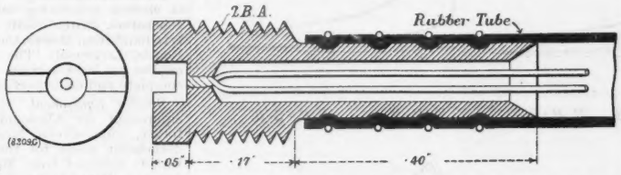


Fig. 9a. VARIATION OF EXHAUST-VALVE TEMPERATURE & B.M.E.P. WITH PETROL CONSUMPTION.

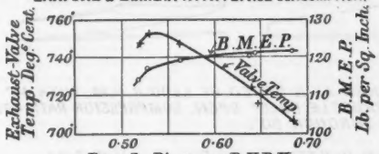
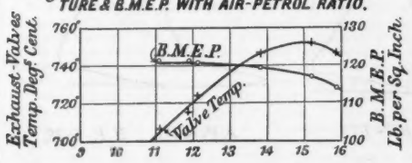


Fig. 9b. VARIATION OF EXHAUST-VALVE TEMPERATURE & B.M.E.P. WITH AIR-PETROL RATIO.



underneath and the other directly opposite this valve. In Test 6 the plane containing the plugs was at right angles to its previous position, so that one plug is now underneath and one opposite exhaust valve No. 2. The effect of the change of plug positions is very marked. The position in Test 6 enables the same power to be developed on a lower petrol consumption. At the same time the temperature of valve No. 1 is considerably reduced and that of valve No. 2 is increased.

TABLE III.

Test.	B.H.P.	B.M.E.P.	Petrol. Pints per B.H.P. hour.	Spark Advance (2 plugs).	Maximum Cylinder-head Temp. T_A.	Exhaust-valve Temperatures.	
						No. 1.	No. 2.
				Deg.	Deg. C.	Deg. C.	Deg. C.
1	35·9	117·2	0·727	15	295	580	Well below 600.
2	35·3	115·2	0·647	14	320	630	
3	34·7	113·2	0·620	12	317	630	
4	33·2	108·6	0·618	12	312	670	
5	32·2	105·2	0·621	12	309	660	
6	34·3	112·2	0·591	12	295	610	590

Generally speaking, it is inadvisable to fit a sparking plug either directly adjacent to, or directly opposite, an exhaust valve. Owing to the compression, during the progress of the explosion, of the gases in the vicinity of the plug, which have already had their temperature raised by combustion, the gas temperatures near this point are higher than in any other part of the cylinder. Unless modified by other influences, the plug side will be the hottest side of the cylinder head, and if the exhaust valve is on this side its temperature and that of its seat will be higher than if it is remote from the plug.

On the other hand, if the plug is opposite the exhaust valve, the compression during explosion of the portion of the charge as yet unburned, takes place against the surface of the hot exhaust valve, and the temperature may be sufficiently raised in this way to produce detonation.

If circumstances render it necessary to place the plug in one of these positions, it should preferably be placed under the exhaust valve.

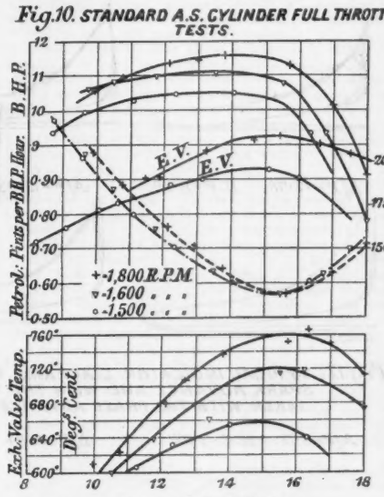
(c) Single Air-cooled Cylinder, 5½ in. by 6½ in., Compression Ratio 5·0 (Fig. 3). *with Single Exhaust Valve 2·3 in. diameter*—Only one series of measurements was made on this valve with the following results:—

Revs.	B.M.E.P.	Petrol. Pints per B.H.P. hour.	Maximum Cylinder-head Temperatures.	Exhaust-valve Temperatures.	Remarks.
			Deg. C.	Deg. C.	
1,650	113·4	0·621	242	760	Maximum load conditions.
1,650	111·6	0·541	262	790	Maximum thermal efficiency.

In these tests the air speed was 80 m.p.h. and the air temperature 18 deg. C.

(d) Single Steel Air-cooled Cylinder, 5½ in. by 6½ in.

Fig. 10. STANDARD A.S. CYLINDER FULL THROTTLE TESTS.



(Fig. 4).—Only a few valve temperatures were measured on this cylinder. These were taken with the petrol reduced to give the weakest mixture capable of developing maximum load, and with the weakest mixture at which steady running was possible. The cylinder-head temperatures were measured at the exact centre—approximately the hottest point—of the head. The results are given in Table IV.

In these tests the air temperature was 20 deg. C., the wind speed 85 m.p.h., the barometer 29·40, and the spark advance 40 deg. The comparatively low exhaust-valve temperatures in this cylinder are due to the very rich mixtures necessary to ensure steady running. By altering the valve timing and the induction pipe of the engine it was found possible, at a later date, to run on weaker mixtures and to reduce the petrol consumption by approximately 10 per cent., but no exhaust-valve temperatures could be obtained when running under these conditions. The temperatures would certainly be higher, and in corresponding tests on the multi-cylinder engine—a nine-cylinder radial—at 1,450 r.p.m. and at full load, the three hottest cylinders had valve temperatures of 720 deg., 710 deg., and 640 deg. The remaining valves were below 600 deg. C.

TABLE IV.

Revs.	B.H.P.	B.M.E.P.	Petrol. Pints per B.H.P. hour.	Cylinder-head Temperatures.	Exhaust-valve Temperatures.	Remarks.
				Deg. C.	Deg. C.	
1,450	28·1	99·1	0·955	270	660	Max. load mixture.
1,450	27·5	97·0	0·795	290	690	Weakest mixture for steady running.
1,650	29·7	92·5	1·062	254	675	Max. load mixture.
1,650	28·6	88·8	0·770	278	705	Weakest mixture for steady running.

(7) *Water-cooled Cylinders.*—Except where otherwise stated, the data in the following sections refer to the Standard A.S. cylinder (shown in Fig. 5). Comparisons are made between the performance of this and of the modified cylinder with less adequate head cooling at a later stage of the paper.

In these tests six compression ratios were used, ranging from 4·01 to 5·19, and with each ratio trials were run at speeds of 1,500 r.p.m., 1,600 r.p.m., 1,700 r.p.m. and 1,800 r.p.m., and over a full range of mixture strengths. The effects of spark advance and jacket water temperature were studied at each compression ratio, and, in

general, at 1,800 r.p.m., while the influence of power (quantity governing) and tappet clearance, &c., were made at one or two compression ratios only.

Owing to the very large number of tests involved, it is not thought advisable to reproduce the results in detail. Typical tests have been chosen to show the effect of each independent variable, but any general conclusions are based on the results of the whole series of tests.

Except when considering local variations of temperature in the cylinder head and the effect thereon of the position and conditions of the water inlet, the thermo-couples in the head have been grouped as under, the mean temperature of the group being recorded unless mention is made to the contrary (Fig. 6).

Fig. 11. TYPICAL INDICATOR DIAGRAMS TAKEN AT A SPEED OF 1,600 R.P.M. WITH 43° SPARK ADVANCE AND WITH THE THROTTLE FULLY OPEN. COMPRESSION RATIO 4·77. TAKEN WITH THE INDICATOR DRIVE IN PHASE WITH THE CRANK.

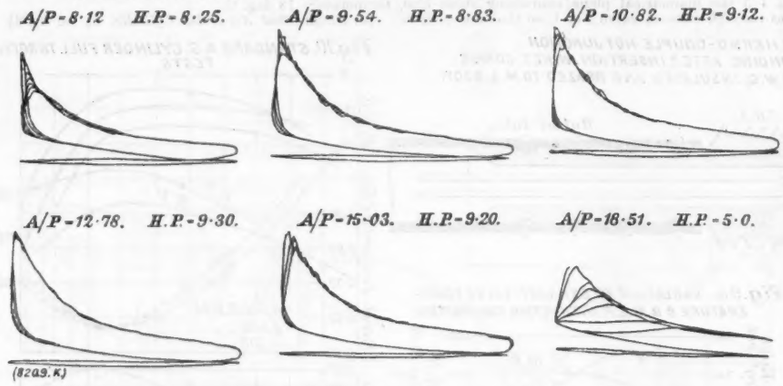
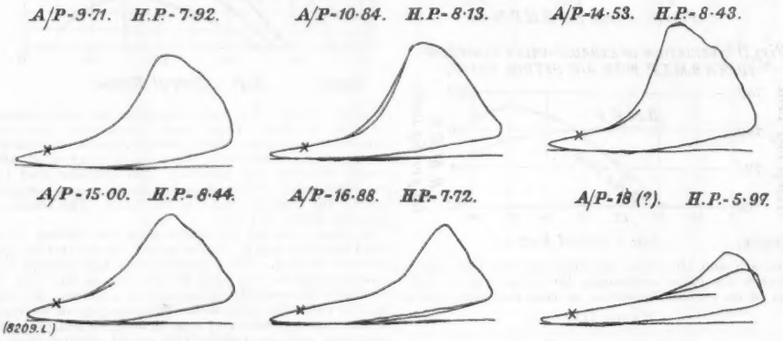


Fig. 12. TYPICAL INDICATOR DIAGRAMS TAKEN AT A SPEED OF 1,600 R.P.M. WITH 43° SPARK ADVANCE AND WITH THE THROTTLE FULLY OPEN. COMPRESSION RATIO 4·77. TAKEN WITH THE PHASE ADVANCED THROUGH 90°.



Group E.V.—Couples B, C, D and I (Fig. 6), surrounding the exhaust valve, the couples just touching the edge of the valve seat.

Group I.V.—Couples G, H and E, surrounding the inlet valve and fitted as above. The couple I, common to the two valve seats, is not included in this group.

Group C.H.—All the above couples taken together.

RESULTS.

(8) *Strength of Mixture.*—In these tests, which were carried out at full throttle, the mixture strength was varied between limits giving a definitely over-rich and a too weak mixture. The spark advance and, as far as possible, the jacket temperatures were kept constant during each series. Except where otherwise stated, the outlet temperature of the jacket water was approximately 60 deg. C. As in the tests on the air-cooled cylinders, the maximum valve temperature is always attained with a mixture slightly weaker than is necessary to give maximum power, and is from 20 deg. to 30 deg. higher than that attained with the latter mixture.

The temperature of the valve first becomes measurable with an air-petrol ratio of about 11 : 1, rising to a maximum with a mixture of about 15·5 : 1, and then falling rapidly as the mixture is still further weakened. The exact A/P ratio giving the maximum temperature varies somewhat with the speed. At 1,500 r.p.m. it is 14·5 : 1, and at 1,800 r.p.m. is 15·5 : 1. It appears to be sensibly independent of the compression ratio. The curves for cylinder-head temperatures follow very closely the form of those for the exhaust valve, but have maxima with somewhat richer mixtures, the maximum head temperatures being attained very nearly with the weakest mixtures capable of developing maximum power, as in the case of the air-cooled cylinders.

The range of cylinder-head temperatures is considerably less than that of the exhaust valve, being about one-fifth of the valve range at 1,500 r.p.m., and one fourth at 1,800 r.p.m. for group E.V., and slightly less for the other two groups. This also is in general agreement with the results of measurements on the air-cooled cylinders.

Table V gives a summary of the results obtained at 1,500 r.p.m. and 1,800 r.p.m. with varying compression ratios.

The general influence of mixture strength on exhaust-valve and cylinder-head temperatures is shown by the curves of Fig. 10, which refer to a compression ratio of 4·77.

Figs. 11 and 12 show typical indicator diagrams taken at a speed of 1,600 r.p.m. with 43 deg. spark advance and with the throttle fully open. The first series was taken with the indicator drive in phase with the crank, the second with the phase advanced through 90 deg. In both cases the A/P ratio has been varied over the full range, giving reasonably steady running. Under these conditions the brake horse-power varies very little over

TABLE V.

Compression Ratio, R.	Air-petrol Ratios for Maximum Power.		Maximum Efficiency.		Maximum Valve Temperature.		Maximum Cylinder-head Temperatures.	
	1,500	1,800	1,500	1,800	1,500	1,800	1,500	1,800
4·01	13·5	14·0	14·7	15·7	14·5	15·5	—	—
4·26	14·0	14·3	14·7	15·8	14·5	15·4	—	—
4·48	14·3	14·5	14·8	16·0	14·7	15·5	—	—
4·77	14·3	15·0	15·0	15·8	14·8	15·6	—	15·1
5·07	14·3	15·3	15·3	16·2	15·0	15·7	—	15·3
5·19*	14·0	14·5	15·0	16·1	14·7	15·5	—	15·3

* These results are probably affected by the fact that at this compression ratio pinking took place except with rich mixtures.

the range 12 : 1 to 14·5 : 1, while the mixture giving minimum consumption per brake horse-power is about 15·2 : 1.

It will be noted that both the height and uniformity of the diagrams are greatest with the weakest mixture capable of giving maximum power, and that the time from the passage of the spark to the attainment of maximum pressure is then a minimum (about 0·0053 second). A variation of the A/P ratio from 14·5 : 1 to 9·7 : 1 increases the time of explosion by 18 per cent. and decreases the brake horse-power by about 6 per cent.

The effect of weakening the mixture is very marked. With the mixture giving maximum efficiency the time to reach maximum pressure is increased 24 per cent., and the mean effective pressure is decreased some 15 per cent., while with the weakest mixtures used the time to reach maximum pressure is almost doubled, and the mean effective pressure is reduced by over 50 per cent.

(To be continued.)

CATALOGUES.

Reflectors.—The General Electric Company, Limited, Kingsway, London, W.C., have sent us a special catalogue of their silvered-glass reflectors for shop window and similar lighting.

Electric Welding Machines.—Machines for butt-welding, spot welding, seam welding and rivet heating are illustrated in special leaf catalogues issued by the M.P. Electric Welding Machine Company, 28, Hatton Garden, London, E.C. 1. Prices are mentioned in some cases.

Marine Oil Engines.—Messrs. Burmeister and Wain Limited, Copenhagen, have sent us an interesting pamphlet comparing the working costs and capacity of their oil-engined ships with steamships. Messrs. Harland and Wolff, Limited, Belfast, are the licensees for building the engines in this country.

Ventilators.—The construction and installation of ventilators of various types, of air inlet panels, gratings, pipes, &c., and ventilating fans, are described in a special catalogue to hand from Messrs. Ewart and Son, Limited, 350, Euston-road, London, N.W. 1. The materials and fittings are illustrated and prices are quoted in all cases.

Electrical Machinery.—A new edition of their catalogue of electric generating sets, separate generators, motor generators, switchboards and other electrical apparatus, is to hand from Messrs. Campbell and Isherwood, Limited, Bootle, Liverpool. The machines are made for either marine or land service and the catalogue gives very complete and clear particulars.

Smithy Equipment.—Some useful and strongly-made equipment for blacksmiths' shops, such as portable forges, hand-driven fans, water boshes, tue irons and detachable noses for tue irons, is dealt with in some leaflets received from Messrs. William Allday and Co., Limited, Paradise-street, Birmingham. The detachable nose allows the quick replacement of the most destructible part of the forge, without dismantling the tue iron, &c. The fans, or blowers, are geared up to 37½ or 47½ times the speed of the handle drive, and the gear-case is designed to retain the necessary lubricant. Prices and dimensions are mentioned.

Cranes.—A catalogue of steam and electric cranes received from the Bedford Engineering Company, Bedford, contains a general specification of the standard details of construction followed by full tabulated particulars of locomotive and stationary cranes for lifting loads ranging from 1 ton to 10 tons; A list of extra fittings, such as buffers, blocking beams, &c., is given, and several types of excavating grabs are shown. Particulars are also given of a series of electric pedestal cranes, electric overhead travelling cranes, a mono-rail crane with overhead steadying guides, and several smaller types of cranes, crabs and hoists, including some operated by hand power. There is also a list of accessories and spare parts for which prices are quoted.

Steam Turbines.—The catalogue of steam turbines issued by Messrs. Peter Brotherhood, Limited, Peterborough, will be studied with interest by those who wish to follow current practice with this class of prime mover. The catalogue sections deal with general design and with the principal parts in detail, and also explain the application of the turbine to the driving of textile mills. Some useful calculations on the economy of special turbines for supplying both driving power and heating steam are also given, together with technical tables and notes, and illustrations of turbines constructed by the firm and now in service. The latter are shown driving a 3,000-kw. alternator; a 500-kw. generator, and various smaller machines such as compressors, gas boosters and pumps.

Electrolytic Plant.—A description of Mr. A. Edgar Knowles's patent plant for producing electrolytic oxygen and hydrogen is published in a catalogue received from the International Electrolytic Plant Company, Limited, New Crane-street, Chester. Many of these plants are at work, but that described is installed at the Erith Oil Works, Limited. The plant normally employs a current of 2,000 amperes, but can be worked continuously with a current of 3,000 amperes if desired. The cells are operated from the works supply, which is direct-current at 210 volts to 220 volts. The purity of the gases produced is 100 per cent. in the case of hydrogen and fully 99·6 per cent. in the case of oxygen. The mechanical and instrument equipment is considerable and the description of the plant is of exceptional interest.

Temperature Measuring Instruments.—The Cambridge and Paul Instrument Company, Limited, 45, Grosvenor-place, S.W. 1, have sent us a copy of a booklet illustrating and briefly describing the wide range of temperature-measuring instruments they manufacture for all classes of industrial work. The booklet is the first of a series to be issued in the near future, giving particulars of all the firm's products, which include engineering instruments, electrical measuring instruments, physical, physiological and medical instruments, and instruments for special purposes, as well as the temperature-measuring apparatus dealt with in the one now to hand. The object of the booklets is to give the preliminary information likely to be required by prospective users in a concise and easily-portable form, reference being made, in the case of each class of instrument, to the numbers of trade lists from which further particulars can be obtained. The first booklet covers mercury-glass thermometers, dial and index thermometers, thermographs, distant-reading thermometers, and pyrometers of the resistance, thermo-couple, radiation and optical types, as well as the complete apparatus for automatically controlling the temperature of furnaces, ovens, steam-heated vessels, &c. This little book seems to have achieved its purpose extremely well, and if the same standard is maintained in subsequent publications, the complete series will form a useful addition to the practical engineer's library

THE MODERN ROTARY DRILLING SYSTEM.*

By L. R. McCOLLUM.

SINCE Colonel Drake, of first oil-well fame, brought in the discovery well at Titusville, Pennsylvania, in 1859, the percussion, or cable tool method of drilling which Colonel Drake used, has changed but little in principle. The cable tool system proved to be a reliable method for drilling in most fields, and its use has been widespread throughout the United States, and in many foreign fields. Exploitation work in the Gulf Coast regions of Texas and Louisiana, however, encountered unconsolidated, soft and caving formations, which gave the cable tools a bad time. To combat these conditions the rotary system was invented or rather developed upon the Fauck system, which had been in use in Europe since 1845. By this method a rigid stem of pipe rotates a fish tail—or other type of bit—at the bottom of the hole, being assisted by the action of clay mud in the fluid state, pumped under hydraulic pressure, through the drill pipe. The circulating mud also removes the cuttings from the hole.

This improved method, the rotary system, had its inception in the Spindletop field of Texas, and in the course of some eighteen or twenty years has drilled approximately 25,000 wells. The extreme speed attained with this type of equipment, and the few strings of casing necessary, are its chief assets. It is not unusual in a rotary field for a good crew to average 450 ft. of hole per day. Wells have been drilled to a depth of 5,000 ft. with only two strings of casing. The rotating action of the bit and drill stem causes the mud to be thrown against the walls of the hole, plastering them thoroughly and penetrating porous formations to a very small extent, where it "muds off" water and gas. This mudding of the walls saves casing, and prevents water and gas troubles, as the static pressure of the mud in the hole tends to balance excessive gas and water pressures.

One of the objections which is continually being raised against the rotary system by operators unfamiliar with its working, is that there is the danger of muddling off unknown oil sands. To obviate this there has been evolved what is known as the combination rig. In this system, the derrick and machinery are provided for both types of drilling, and if conditions are met which, for any reason, cause the findings of the rotary to be questionable, then the cable tools may be brought into play. The combination system is employed to a large extent in known fields where the rotary is generally used to drill through the upper formations at great speed, effecting a tremendous saving in time, trouble and expense, and the cable tools are used finally to drill into the oil sand.

If accurate logs of wells in a new locality are kept, and if, as is very desirable, core barrels are run and core taken with the rotary equipment, it is easily possible to calculate the underground formations of the field, and if desired, do away with the cable tool feature of the combination using straight rotary only.

In the Gulf Coast fields a light type of equipment is generally used, in view of the comparatively shallow depths drilled and the easy formations to be penetrated. The weight of the rotary machine used under these conditions is about 4,600 lb., but in California, where the heaviest equipment is necessary, the weight of the machine is over 8,000 lb. The standard size of rotary has a table opening of 20 in. in diameter, but the heavy machine used where it is desired to commence and finish a well with large diameter casings, is provided with a 27½ in. diameter table opening. In California, where the rotary has drilled as deep as 7,200 ft., the heaviest and best constructed machinery is necessary.

In the rotary system the drilling tools consist of a flat bit in the form of a fishtail mounted on the bottom of a string of drill pipe extending to the surface, where it is grasped and rotated by the table of the rotary machine mounted on the derrick floor. The whole string of drill pipe is suspended from the tackle fitted with a swivel attachment so that the bit may be raised and lowered and its pressure on the bottom regulated.

While drilling is proceeding mud-laden fluid is pumped through a flexible hose to the connection of the swivel, down through the hollow drill stem and out through holes in the bit. Here it mixes with the cuttings and carries them up between the drill pipe and the walls of the hole to the surface. The mud-laden fluid plays a very important part in rotary drilling, and it is important that it should contain only very finely-divided clay. It usually has the consistency of thick cream and a specific gravity of 1·4. The hydrostatic pressure of the column of mud enables high pressure gas strata to be penetrated with no danger of a blow-out. On its upward passage outside the drill pipe a proportion of the mud adheres to the walls of the hole, and plasters them to such an extent that any tendency to caving is overcome.

The rotary rig includes the derrick, or tower, and foundations for rotary machinery. It is built by a crew of rig builders in the average time of 35 man days. The derrick supports the crown block, which carries pulleys or sheaves over which the hoisting lines pass. The rotary derricks vary in height from 112 ft. to 130 ft., and are 24 ft. square at the base; 120 ft. by 24 ft. is the ordinary size. These derricks are made extremely high in order that the drill pipe may be withdrawn, dissembled, and set back in the derrick in "stands" of four joints each (each joint of pipe being about 24 ft. long). This greatly reduces the work of taking out and replacing the drill pipe when changing bits.

A wood-lined pit about 10 ft. square by 10 ft. deep is constructed just outside the derrick floor. This serves for mixing and storing the mud, and as a suction box for the pumps. About 100 ft. of wooden ditch conducts the mud from the top of the casing back to the mud pit. Here occurs the precipitation of the cuttings from the mud. The cuttings are shovelled out of the bottom of the ditch and disposed of, and the mud returns to the pit to be used again. Often very elaborate settling boxes are arranged in this ditch system.

Power is supplied by steam, gas or electricity. When steam is the method employed it is usually supplied by one large, portable fire tube, locomotive type boiler. In very deep fields two or three boilers totalling about 140 h.p. are commonly used. The twin-cylinder engine has several decided advantages over the single in rotary drilling in which it is continually necessary to reverse the engine rapidly when the bit encounters a break in the formation, or a boulder which it cannot penetrate nor dislodge. Unless the twisting force on the drill pipe is quickly relieved, the pipe will be broken in two. It takes some appreciable time for the impetus of the heavy fly-wheel on a single cylinder engine to be overcome and the engine reversed, but the reverse can be accomplished immediately with the twin engine.

In many fields where electric current is available, rotary rigs as well as cable tool outfits are being operated by electric motors. The standard equipment for running a rotary rig by electricity is a 75 h.p. induction-type motor, of 50 or 60 cycles. For gas and oil engines which are also used in rotary drilling the usual installation is a heavy oil country-type 75 h.p. engine, which will run on either natural gas or a low grade distillate. When an internal-combustion engine is used the drive is stepped up from the engine to the line-shaft *via* a countershaft.

The draw works serve as a two-speed hoisting gear for handling the drill pipe and as a transmission between the engine and the rotary machine. It consists essentially of three heavy, vertical timber posts, framed into the side of the derrick. The tendency is for the rotary machine to be run at continually increasing speeds. There is now available a three-speed rotary draw works, which renders it possible for drilling to proceed at a greater rate. The clutches on the draw works are now operated by foot pedals.

The rotary machine for gripping and turning the drill pipe consists of a heavy horizontal steel turn-table, carried by a heavy annular cone roller bearing on a massive base. The drill string, the upper or working joint of which is square, passes through a square hole in the table, and is driven by suitable bushings engaging both table and drill stem. The table has gear teeth on its under side, which are engaged by the pinion on the pinion shaft, driven, either by a sprocket chain from the line shaft of the draw works, or by a direct-shaft drive.

A recent introduction is the embodiment of mechanism in the rotary table for screwing up and unscrewing drill pipe and casing. For this type of rotary it is claimed that much time is saved in performing these operations in the hands of experienced and careful drillers. The design has the disadvantage of requiring a considerable amount of complicated mechanism in the rotary table which is liable to serious wear and damage; also, of course, the initial cost of the machine is much higher. Another development which is now being experimented with is the regulation of the feed of the rotary bit on a steam or electrically-driven rig. By means of regulators, when a torsional strain is placed on the bit nearly sufficient to cause a twist-off, the entire string of drill pipe is automatically raised to relieve the pressure. This device is at present in a purely experimental stage.

In order to ascertain the weight on the bit, and to regulate this weight according to requirements, various types of stress indicators have also been developed. The most reliable at present in use is placed in the dead line between the crown block and casing block, and it therefore actually registers the strain in the line, minus a slight friction of the ropes in running over the sheaves. It is a simple matter from the strain indicated and the number of lines used to calculate the dead weight in the well.

Another device to serve the same purpose is used on several of the Shell Company's wells in California. In this case advantage is taken of the compression of the derrick legs to indicate the weight hanging in the well. The driller determines what length of pipe he will allow to rest on the bit and proceeds to set a zero mark on the indicator for this weight. Any more or less weight on the ropes will throw the recording needle to either side of zero. Though this idea may appear crude it has been developed to the point where it gives satisfactory service, and can be used by any driller without special training.

The mud-laden fluid is circulated by two powerful direct-acting duplex steam pumps, working alternately. The abrasive action of the mud causes the packing on plungers and valves to be comparatively short-lived, and these are designed for easy replacement. The two pumps permit of continuous circulation (if necessary), one pump operating and the other kept in reserve. Each pump has a separate suction pipe to the mud pit. The discharges are connected by a manifold to a stand pipe running for about 20 ft. up the side of the derrick. A flexible hose connects the top of this pipe with the swivel on the drill stem.

Heavy hoisting equipment is necessary for handling the drill pipe and casing. For starting the well a four-line tackle is used, and the number of the lines is increased as the hole is deepened until as many as nine lines are used. The casing line is usually a ⅞ in. or 1-in. wire line. The free end of the line is spooled on the hoisting drum at the draw works. The swivel serves as a swivelling connection between the hook and the rotating drill pipe, and facilitates the introduction of the mud-laden fluid under high pressure. The modern swivel is the most refined piece of machinery on the rotary rig. It is automatically lubricated by the oil bath and gives absolutely no trouble.

The drill stem transmits the rotary motion of the table to the drill pipe. It takes the place of the old grip ring device, which was clamped directly on to the round drill pipe. The drill stems now used are of either square or grooved section, and are drilled with a hole longitudinally through the middle to permit the passage of mud fluid. They are grasped by bushings which fit in the rotary table and engage the drill stem. In the drill stem attachment are also slips for holding the drill pipe in the table when it is being inserted or withdrawn.

The drill pipe generally used is either 6 in. or 4 in. size, though when the diameter of the well decreases below 6 in. casing, it is necessary to use smaller drill pipe still. The specification of pipe is generally seamless steel, the ends of each length being internally upset to a double thickness for some distance beyond the end of the threaded portion. It is just at the back of the coupling that twist-offs are most likely to occur, and it is at this point that greater strength and wall thickness are provided by the process of upsetting. Seamless steel material has a tensile strength of about 70,000 lb. per square inch, and is much less liable than lap-welded pipe to twist-offs. When a twist-off does occur, however, the break is generally clean, so that there is very little difficulty in fishing. As previously mentioned, the drill pipe is generally made up in stands of 4 lengths each, so that a tapered tool joint is required at every 4 lengths, or approximately 96 ft. These conical screwed joints with coarse threads facilitate the assembling of the drill pipe. It is common practice now for the collars on the drill pipe when it is made up in stands to be "spot welded" to the pipe, so that the joint is practically solid.

For ordinary drilling in everything but very hard rock, the fishtail bit is used. This is a simple steel bit and can be easily redressed when worn down or out of gauge. The diamond point bit is used only in special cases, for example in drilling past lost tools or side tracking pipe or other objects lost in the hole. The 4-way bit is sometimes used to ream the hole prior to the insertion of casing, but it has certain disadvantages, and the use of a rotary under reamer is far preferable. The rotary system can penetrate even the hardest of rocks by the use of special bits. There are various types of these, the best known of which are the cone rock bit and the disc bit. The cone bit is provided with two circular grooved and drilled cones mounted at the bottom of a heavy bit body, which revolve and crush the rock as the drill pipe is rotated. The disc bits consists of a heavy body with two sharp-edged discs mounted at the bottom slightly eccentrically. When this bit is rotated the discs exercise a slicing action.

Before the actual drilling is started, a hole about 3 ft. or 4 ft. square is dug by hand below the derrick floor to a depth of 8 ft. or 10 ft. and lined with a wooden box, which serves to collect the rotary mud and conduct it to the mud ditch. As the bit penetrates the formation it is lowered by releasing the brakes on the hoisting drum of the draw works, permitting the drill stem to slide down through the driving bushings.

A subject which has been very extensively discussed, and on which opinions vary considerably, is the action of the mud-laden fluid in a well being drilled by rotary. Horizons of high gas pressure are successfully penetrated by the rotary with no special precautions. From the time the well is started until the casing is set, the hole is kept full of mud-laden fluid, and the hydrostatic pressure of this fluid will overcome all excepting very excessive gas pressures. In proven fields, where the depth of the oil horizon is known, wells are extensively brought into production with the rotary. When the oil sand is penetrated the oil string of casing and the tubing are inserted, clear water is pumped down between the casing and the tubing, forcing the mud-laden fluid out through the tubing. This washes the mud from the sides of the oil-bearing formation, and decreases the hydrostatic pressure, permitting the well to flow. Where rotary wells are drilled in a non-flowing territory, the circulating fluid is thinned by constantly adding water until the washing process has cleaned the strata; after which the fluid is entirely bailed out and the well is brought in and pumping equipment is installed.

With the object of securing definite information on the action of mud-laden fluid in a rotary drilled well, various experiments have been carried out, not only with laboratory apparatus, but on the field, the objects being to ascertain the relative penetrative effect of clear water, and of mud fluid in different kinds of formations. The laboratory experiments have included the forcing of water and mud fluids of different specific gravities through a column of sand under known pressures. The result of these laboratory experiments proved that the clay mud quickly adhered to the sides of a channel cut through a column of sand, and this mud wall remained permanent whether circulation of the fluid was continued or not. When water was slowly circulated through this channel a certain amount of the plastered clay was washed away, but a stable condition was soon reached, after which there was no more erosion, and water circulating indefinitely remained clear. After the water circulation was stopped, however, the walls commenced to cave almost immediately, and the entire wall soon disappeared.

More definite experiments were carried out by the Union Oil Company, of California, in conjunction with the State Oil and Gas Commission. A sample of rock weighing approximately a ton was used for the experiment, this rock being taken from a formation which has been exposed to the elements for centuries and was free from saturation, either of water or of oil. A 1¼-in. hole, 26 in. deep, was drilled in it, a nipple leaded in the top and preparation was made to raise a pressure of at least 4,000 lb. Water was first put in the hole, and an attempt made to produce pressure, but the formation absorbed the water rapidly. Mud fluid from the rotary sump hole was then substituted, and pressure imme-

* Paper read before the Institution of Petroleum Technologists on December 11, 1923. (Abridged.)

diately began to build up. Pump pressure was kept at 200 lb., all one night, and the next day was gradually increased to 400 lb., at which point the rock opened at the seams, which originally were only just discernible. As no further mud could be forced in, the rock was broken up into numerous sections. In no one of the dozen parts observed was there any indication of the mud having penetrated even a fractional part of an inch, although when freshly broken the travel of the clean water first put in could be plainly observed.

Later, another sample of the same formation, weighing 50 lb., was taken and divided equally in half. One of these pieces was submerged in water for 2 hours, and upon its removal was found to have absorbed 3 lb. weight of water, and after a further submergence of 24 hours had absorbed only a few ounces more. The other block of rock was placed for 24 hours in a tank of 24 gravity oil straight from the well. At the end of 24 hours it was weighed and found to have absorbed practically the same amount in weight of oil as the first sample had of water.

These experiments, with sand, porous rock and different formations, conclusively proved that whereas water and oil were rapidly taken up, the mud-laden circulating fluid only created a film or deposit on the inner wall or lining of the hole. The nature and specific gravity of the mud fluid has a considerable effect on the speed of drilling. A uniform mud will make holes faster than mud which is thinned at intervals. Since mud thickens continually during the drilling operation, it will eventually get so thick that drilling is retarded, and it will become necessary for more water to be added to the sump. This operation should be so regulated that the mud will be always kept at a uniform consistency.

The velocity of the mud fluid also has a very considerable effect upon drilling speed. It has been demonstrated, when drilling in laminated shale, for example, that an increase of velocity from 1¼ ft. to 1½ ft. per second up the hole, carried out three times the quantity of cuttings. Velocities of mud in a well are comparatively low. An experienced driller keeps the velocity as high as possible, without caving the hole, and this is where experience is necessary, although the slightest cave can be detected immediately and means taken to stop it. The velocity in large holes cannot be as high as in those of small diameters, because of a loss of the arch effect in supporting the sides of the hole. In drilling large wells, consequently, the mud must be colloidal and heavy and the velocity relatively low. Cuttings come up slowly although the same velocity brings out the same quantity, but the mud is heavier, due to the large amount of cuttings carried in suspension.

The experiment above referred to, and others, show that the depth of penetration of a low gravity mud fluid into a porous formation is greater than that of a heavier gravity. In general practice mud of a specific gravity of 1·13 gives the best results. Where the hole has been drilled with a mud fluid of this gravity it has been found that the mud wall of the hole is more permanent, and the sand carried in suspension settles out in the mud ditch faster than when mud fluid of heavier gravity is used. For a fishing job in a deep well the use of a lighter gravity mud fluid sometimes proves a great disadvantage, as the sand held in suspension may settle around the lost tools, freezing them before it is possible to run the fishing tools into the hole.

The formations encountered in rotary drilling can be satisfactorily recorded by the expert driller. He can easily tell by the action of the machinery when he encounters a change in formation, and samples of this formation can be taken from the rotary mud flowing to the surface, making an allowance for the time needed by the mud to travel up the hole. Where very accurate samples are advisable, a core barrel is used. This is substituted for the bit, and brings up an intact section of the formation.

Opponents of the rotary system invariably cite, as an argument against it, a supposed inability of the system to sample accurately the formations passed through. This argument might have been used in the early days of the rotary, and against any other system in the early stages of its development. However, recent developments in core barrels have made it possible to take exact samples of the formations drilled at any depth, and many wells in California are now being drilled, taking cores continuously. Core barrels are of both the single and double barrel type, and on most of the single barrel types the circulating mud fluid is from 3 ft. to 20 ft. from the cutting edge of the barrel.

If too much weight is put upon the core barrel during rotation, high temperatures are soon generated by the friction. These temperatures were in many cases above the fusion point of the formation being cored which resulted in obtaining cores that were badly fused and so badly metamorphosed that they gave no information about the formations from which they were taken. The double core barrel is constructed with the object of overcoming the difficulty of fusing cores. It is provided with means of cooling the barrel itself and of withdrawing the core easily. There is an admixture of circulating mud with most core samples. Sometimes it occurs as a thin coating covering all of the sample, and in many cases the circulating mud fills cavities in the core, though it is not difficult to distinguish the rotary mud from the actual formation taken from the bottom.

One of the chief advantages of the rotary system is the great saving in casing. The following are comparisons of the casing used in rotary-drilled wells compared to the diameters used in cable tool drilling.

2,400 ft. well.

Rotary.	Cable Tools.
200 ft. 10-in. casing	40 ft. 15½-in. casing
2,400 „ 8¼ „ „	200 „ 2½ „ „
	1,000 „ 10 „ „
	2,400 „ 8¼ „ „

4,400 ft. well.

Surface conductor.	Surface conductor.
3,750 ft. 10-in casing	200 ft. 18-in. casing
4,400 „ 8¼ „ „	750 „ 15½ „ „
	1,450 „ 12½ „ „
	2,500 „ 10 „ „
	3,400 „ 8¼ „ „
	4,000 „ 6¼ „ „
	4,400 „ 4½ „ „

With the rotary it has been possible to finish a well for production to a depth of 5,500 ft. in approximately 120 days. It is becoming common practice in the Californian field to finish wells 1,800 ft. to 2,500 ft. below the last shut-off point. This necessitates setting an oil string with 1,000 ft. to 2,500 ft. of friction.

In the Long Beach field the conductor casing is cemented at depths varying from 600 ft. to 1,000 ft. This string cases off the loose surface formations and also provides means of anchoring the water string. Water strings are cemented between 2,300 ft. and 4,500 ft. It has been found advantageous to maintain the largest size hole possible, so that the well can be deepened if desired. On account of the great amount of friction on long strings, it is the general practice in the field, after setting one string, to omit the next succeeding size and set the next smaller size—*i.e.*, if 10-in. casing is used for the water string, 6¼-in casing is used for the oil string. The oil string is landed with screen pipe on the bottom, usually extending to the shoe of the water string and open to the full thickness of the productive oil measures.

Another casing combination frequently employed is as follows: A 27-in. diameter hole is drilled for the 18-in. conductor casing, and after cementing this string a 17-in. hole is drilled to the cementing point, where the 11-in. casing is inserted for the water string. The hole is then reduced to 10⅝-in. diameter, which size is carried to the cementing point of the 8¼-in casing. After setting this string a 7⅞-in. hole is drilled to the completion depth, which is sufficiently large to set the 5 9/16-in. liner. Six-in. drill pipe is employed in drilling the hole to the cementing point of the water string. After this has been set the 6-in. drill pipe is broken down and replaced with 4-in., which is used in the 11-in. and 10-in. casings. To drill in through 8¼-in. and 6¼-in. casings 3-in. drill pipe is customarily used, as it is easier to recover in the event of a fishing job.

These long strings of casing, some of which weigh over 100 tons, are now successfully landed and cemented with great rapidity. This is commonly done in California, using a special type of check valve and a particular pattern of shoe guide or floating plug. The check valve closes when the pressure on the outside is greater than that inside the casing. It is customary to place the check valves in the shoe guide, the casing shoe being threaded for both, and as each joint of casing is introduced it is filled with water until approximately 1,000 ft. has been set in the well. The pressure inside and out up to this point is equalised.

From there on no more water is added for a considerable depth, and this practically makes of the string of casing a float with the weight at the bottom. It is easily possible by proper manipulation to actually float this string to the desired position with very little, if any, strain on the casing line, brakes or draw-works. When the string is landed the casing is filled to the surface and the pump started. As soon as the pressure inside exceeds that outside the pump will force the mud fluid or cement through the shoe guide up outside the casing. After the casing is set the check valve and floating plug are drilled up. By this means many of the wells at Santa Fé Springs, California, have set as much as 3,800 ft. of 11-in. by 60 lb. casing of a total weight of approximately 230,000 lb. Other strings set in similar fashion include 5,282 ft. of 8¼-in. by 36 lb. casing and over 5,500 ft. of 6¼-in. by 26 lb. casing, weighing even more than the strings of larger pipe. This method of floating in casing has the advantage of greatly reducing the impact if the casing parts and falls to the bottom.

Long strings of drill pipe are also run in the wells by similar means, a check valve being inserted at some point above the drill collars. Ten years ago, 95 per cent. of all drilling in California was done with cable tools, whereas at present over 95 per cent. is done with rotaries. In Texas and Arkansas 100 per cent. of the drilling is accomplished with rotaries, except in the Breckenridge district.

The process of cementing is used almost exclusively for making a water-tight joint at the bottom of the casing. Cement is pumped down through the casing which has been lifted off the bottom a few feet, and up around the casing outside. Sufficient water is pumped in on the top of the cement to force it all out of the casing, which is then lowered to the bottom. Some modifications of this system use wooden plugs ahead of, and behind, the column in order that it will not mix with the mud and water.

When all the cement is out of the casing and the upper plug encounters the lower one at the bottom of the hole, the pumps stop owing to the back pressure, and valves at the casing head are closed. The well is then allowed to stand some days until the cement is set. In some cases where there are thick clay formations, the casing is pressed some considerable distance through the clay to effect a water shut-off if the source of the water is not very strong.

Fishing jobs with the rotary system are few and simple, nearly all are caused by the drill pipe twisting off. A simple device, known as an overshot, is run down on the recovered pipe. This is passed over the upper end of the lost pipe and springs attached to its inner surface catch under the first collar of the lost pipe, when it can be pulled to the surface.

Besides the overshot, the taper tap is sometimes used. This tool is run into the hole in the same manner as the overshot and enters either a water course in the tool joint or the inside of the drill pipe. A slow, careful rotating motion is applied, and the tap cuts a thread, makes its own connection, and becomes a perfect joint. The lost portion is thus removed. The trip or wash down spear and the wall hook are employed as in cable drilling, except that they are attached to, and run on, the drill pipe.

One of the most remarkable examples we have of the successful development of a field by the rotary system is the Tonkawa field in Oklahoma. The conditions here presented more difficulties than any other Oklahoma territory. The records of 12 wells completed by cable tools in the early development of the field show that it required an average of 147 days for each well. An average compiled from 12 wells drilled by rotary tools and completed by cable tools shows that similar wells were completed in fifty-one days, including cementing casing, standardising the rotary rig and drilling in with cable tools.

At Tonkawa drilling conditions are extremely hazardous for cable tools. Several shallow gas sands above 1,000 ft. made blow-outs frequent, and a number of gas wells completed at these depths produced as much as 50,000,000 cub. ft. daily. Such quantities of mud were required to hold these gas pressures back that progress with the cable tools was very slow. After passing through the gas sands, caving formations were encountered which made it necessary to carry the pipe close behind the tools. This made collapsed pipe, frozen pipe, with their consequent fishing and underreaming jobs, so frequent that cable tool contractors spent many weary months in penetrating the formations, and in the big majority of cases actually begged to be relieved of their contracts.

The following is the log of a typical rotary well drilled: Drilling began on September 5, 1922, the day the cable tool hole was plugged as a failure. On October 17, a little over forty days later, the well was drilling at 2,000 ft. On November 7, the 8¼-in. casing was set at 2,432 ft., and the derrick was prepared for the reception of the cable tools. On November 28, the cable tools were drilling at 2,505 ft. in 6¾-in. casing. On December 3, 5 9/16-in. casing was set at 2,610 ft., and on December 9 the drilling was finished, resulting in a 650-barrel well at 2,621 ft., the total time consumed being 94 days.

In this field there is about 500 ft. of hard limestone, found in strata of various thicknesses to be penetrated. From 14 to 20 sets of rock bit cones are used up on each well. Other wells drilled in this field by the rotary have reached 1,833 ft. in 21 days, and 1,950 ft. in 24 days, and as formations became better known the drilling speeds were increased. Later on permission was granted to complete the wells with the rotary, resulting in the bringing in of the Tonkawa wells on an average of 45 days to 50 days.

The foregoing exposition clearly demonstrates that many of the objections advanced against the rotary system do not now really exist, and every day its many advantages are becoming more thoroughly understood.

The obvious facts in favour of this system are:—(1) High gas, water or oil pressures can be easily and successfully controlled; (2) a more accurate log can be obtained by liberal use of the core barrel; (3) the oil-bearing formations are not subject to continuous penetrations by water or mud; (4) less time is required to complete the well; (5) less casing is required; (6) wells are invariably completed at a lower cost.

Norwegian Shipbuilding.—The Norwegian shipbuilding industry is suffering from great depression at the present time. There is a general shortage of employment, and the number of hands has in many instances been greatly reduced. There appears to be no lack of inquiries, but the yards are unable to accept the figures owners are prepared to pay. At Laxevaag the number of hands employed is only one-fourth of the normal. The same is the case at Haugesund. The Kaednes yard employs its normal number of hands building a 10,400 whale-boiling station, a submarine, &c. The Aker yard is building a couple of good-sized boats, but there have been no fresh orders for months, and repairs are few and far between. Other yards report a similar state of affairs.

The Winget Tar Macadam Drying and Mixing Plant.—In connection with the recent Public Works, Roads and Transport Exhibition, we made mention on page 646 *ante* of the tar macadam drying and mixing plant developed by Messrs. Winget, Limited, of 24, Grosvenor Gardens, S.W. 1, and referred our readers to a description of this plant which appeared in our issue of March 23 last (page 364). We find that in the interval since that date considerable alterations and improvements have actually been made in the plant. The elevators to the drying barrel and the dried metal hopper are now of the continuous bucket type, the buckets being arranged close together instead of being spaced apart. Between the drier and the dipping conveyor is an elevator, hopper and completely new device for measuring off the metal from the latter and transferring it to the dipping containers. This arrangement includes a revolving table under the hopper from which the stone is removed by a knife, which diverts it into a small fixed hopper. From this it is discharged into a travelling hopper, which is timed correctly to move forward and deposit the stone in a container, returning afterwards to its normal position. Improvements have been made in the arrangements for giving an intermittent motion to the dipping containers, and a new gear box has been introduced for this purpose. These and other changes made though adding somewhat to the complication of the plant, should certainly result in an improvement of the product; and the plant offers an ingenious solution of several difficult problems.